PHOSPHATED COMPOSTING ON SOIL-PLANT RELATIONSHIP

A

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By

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Dedicated

To Believed

My Uncle

Rama Shankar Rai

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CERTIFICATE

Certified that Shri Ajay Kumar Rai, M.Sc. (Ag) Agri. Chemistry & Soil Science has conducted research work under my supervision on the topic entitled. "Phosphated Composting on Soil-Plant relationship" for the award of the degree of Doctor of Philosophy in Agricultural Chemistry and Soil Science of the Allahabad University. Experimental observations and data presented in the thesis to the best of my knowledge are genuine and original.

Dated. 17.12.2002

(M.M. VERMA)
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CONTENTS

CHAPTER - I

INTRODUCTION

INTRODUCTION

Soils of India are generally poor in fertility as they are low in organic matter and have consistently been depleted of their finite nutrient sources due to continuous cultivation for many countries. The low and dielining soil fertility are the main causes of low productivity of the most of the cultivated lands. Singh (1997) pointed out in his presidential lecture that nutrient deficiency in India show N deficiency as universal and nearly 49, 20 and 47 per cent soils of India are deficient in P, K and Zn respectively. Sulphur deficiency is recorded in 125 districts. The Fe, Mn and B have also become most serious constraints in some agricultural production systems. The long - term fertilizer experiments being conducted in different agro-ecological regions have demonstrated very clearly that in future K deficiency in most of the soil under intensive cropping.

Indian agriculture is operating as a net negatives balance of plant nutrients at the rate of 8-10 million tons/annum. This continuous nutient imbalance can become staggering when we consider the future need of food production to the tune of 301 million tons food grains by the year 45 million tons of plant nutrients. Demand of chemical fertilizer would be 35 million tons consisting of 5.6 - 8.8 million tons P_2O_5, 2.3 to 4.7 million tons K_2O and the rest of the nitrogen. At least 10 million tons of nutrients should come from organic manures, crop residues and bio-fertilizers. Thus, food security is very much linked with fertilizer input.

Composting is the biological decomposition and stabilization of organic substrates, under conditions that allow development of thermophilic temperatures as the result of biologically produced heat to produce a final produce that is stable free of pathogens and plants seeds, and can be beneficially applied to land. The processes are characterized by a period of rapid decomposition and self-heating followed by a cooler, slower decay of remaining organic substrates. Regulating the kinds of organic substrates and controlling the physical and chemical attributes of the decomposition environments in the compost pits facilitate to process. Manipulating moisture content, pH, nutrient concentration and oxygen can bring about increased decomposition rates and change the characteristics of compost. Known to backyard gardeners as a soil-enriching additive, compost promotes plant productivity and soil quality. Hang (1993) described that an nouncements in modern engineering have resulted in the growing use of composting for municipal and industrial waste treatment and nutrient recovery. The same microbial processes and used by both large commercial composting industries and by backyard gardeners, although the former may produce thousands of cubic meters of compost while the latter only a few.

Composting to manage organic waste produces several advantages:—

- Compost generally poses a low risk to the environment assuming it is free of heavy metals or hazardous organic materials.

- Compost improves soil fertility whether in backyard gardens or reclaimed stripmine soils.
- Composting is compost competitive with other wasts handling technologies.

Most organic wastes can be successfully composted for example, paper and food wastes often comprise 50% of municipal solid waste. Both are well suited to composting bio solids (sewage sludges) animal manures, and agricultural crop and food processing wastes are also excellent materials for composting. Most of their wastes, however, are presently placed in landfills. These materials are suitable substrates for composting because they contain carbohydrates, proteins, and lipids that the microorganisms can readily degrade.

Most organic substrates carry an indigenous population of microbes from the environment. Representatives of three major groups of bacteria, actinomycetes, and fungi of soil microorganisms are normally present when the composting process begins. Microbial population change during the composting process, as shown in table as describable by Poincelot (1982) progressing from the mesophilic stage (above 40° C) and then through a gradual cooling period, the final stabilization or curing stage.

MICROBIAL POPULATION CHANGE DURING COMPOSTING

Organism	Mesophilic stage	Thermophilic stage	Stabilization curing stage	No. species present
	CFU g^{-1} dry mass			
Bacteria				
Mesophilic	10^8	10^6	10^{11}	6
Thermiphlic	10^4	10^9	10^7	1
Actionomyectes				
Thermophilic	10^4	10^8	10^5	14
Fungi				
Mesopilic	10^6	10^3	10^5	18
Thermophilic	10^3	10^7	10^6	16

Microbes are inefficient in trapping energy released during the oxidation of organic substrates. Energy that is not biochemically captured in the catabolic degradation of organic substrates is dissipated to the environment as heat. When organic matter decomposes over a large area of ground, the heat dissipates in to soil, air, and water, and the heat increase is searcely noticeable. In contrast, compost piles restrict the free dissipation of heat generated during decomposition, resulting in significant temperature increase.

The activities of several enzymes have been monitored during composting (Hankin et. al. 1976). For example, cellulose activity decreases the amount of cellulose present by about 25% in about three weeks lipase, protease, and amylase activities rise and fall during the

successive stage of composting. Activities of all these enzymes decrease sharply during the thermophilic stage, probably because of heat inactivation. The denaturation of enzymes is often correlated with the depth of the microbe. This suggests that the apparent recovery of microbial numbers and enzymatic activity in the pile interior often the thermophilic stage is due to reintroduction, during turning, of organisms that survived of the outer, cooler parts of the pile.

The subject of adding superphosphats, dicalcium phosphate, or rock phosphat during composting has engaged the attention of scientists since long (Acharya 1954 , Walunjkar and Acharya 1955, Dhar 1962, Murthy 1970). Reports about the usefulness or other wise of adding souble P- sources to organic manures yield variable results (Acharya 1954, Fuller and Nielson 1957; Singh and Subbiah 1969, Subbiah and Mohan 1965) . The soluble phosphates are expected to remain largely as such. A small amount of immobilization of soluble P into microbial P may be expected but with most plant materials containing sufficient P to satisfy microbial demands during decomposition, the assimilation of P from external sources is seldom needed.

The addition of insoluble source of P to enrich compost is a more rational and practically useful approach, since solubilization of insolublic P occurs during composting. Early work showed that by adding rock phosphate to farm composting material to a thickness of about 6.5 mm/layer of farm refuse, nearly 50-70% of insoluble P was made soluble and was readily absorbed by the plants (Acharya 1954).

However, no quantitative data were provided regarding the P_2O_5 contents and other nutrients in the finished compost Mishra et al. (1986).

The compostable material consisting of crop residues, grasses, weeds, tree leaves, animal feed wastes or their mixtures, and cattle dung, well decomposed compost and soil are taken in a ratio of aproximately 8:1:0.5:0.5 and mixed with Mussoorie Rockphosphate at the rate of 25% the compostable material on dry weight. Cattle dung, biogas slurry and FYM, compost or sewage sludge provide active decomposers and nutrients. Their amounts can be changed depending on availability. Soil helps to reduce N losses. The mixture after adequate moistening is put in pits and allowed to decompose for three months.

The compost called 'Phosphocomost' or phosphated compost is ready in three months and contains between 6.0 - 8% total P_2O_5 depending on the degree of decomposition. There is significant transformation of soluble P present in the original Mussorie rock phosphate and about 50% of the in soluble P is converted into citric acid soluble (available) forms. The water soluble or bicarbonate soluble P do not increase due to reaction of soluble P with the free $CaCO_3$ present in abundance in MRP. Enrichent with MRP beyond 25% does not increase P solubilization further. The total N content of phosphocompost is lower than that of corresponding compost due to the dilution effect.

Application of phospho-compost significantly increased soil organic matter, soil micribial biomass, soil basal respiration and activity of enzymes such as dehydrogenase, cutalase and phosphates over sale application of mineral fertilizer possibly due to the fact that organic matter had been used as a source of carbon for soil organisms but the magnitude of increase or these parameters were less in the plots were only mineral fertilizers were applied. In regard to respiration, the substantial amount of CO_2–C evolution was absorved in rice fields when the plots received phosphocompost. This indicated that application of compost maintained higher microbial activity by the addition of compost. The soil biological activity and soil fertility status in terms of available N and P were recorded in three year trial in vertisols under rice wheat ystam. (Manna et al. 2000). It was found that there was significant improvement in soil biological activities and available nitrogen in the second and third year by phosphocompost application compared to NPK application. Phosphorus play a role in photosynthesis, respiration energy storage and transfer, cell division, cell enlargement and several other processes in the living plant. It promotes early root formation and growth. Phosphorus improves the quality of fruit, vegetable and grain crops and is vital to seed formation. It is involved in the transfer of heredity trails from one generation to disease resistance in same plants and hastens maturity. Oxalate, tartrate, malate, and malonate, which occur as organic matter degradation production.

In some instances, P adsorption has been found to corelate with soil organic C although this is probably a minor contribution to

P adsorption in soil. The Al and Fe adsorbed by organic colloids are most likely active in P adsorption. Generally, incorporation of green manures results in better utilization of P by subsequent crops. Part of this favourable effect is likely related to the decomposition of organic residues accompanied by the evolution of CO_2. When dissolved in water, CO_2 forms H_2CO_3 which is capable of decomposition certain primary soil minerals. In natural and calcareous soil, increasing CO_2 increase the solubility of Ca- P minerals. Thus on the bais of the available evidence, it is clear that the addition of organic materials to mineral soils may increase the availability of soil P. Recall that soil OM content also is correlated with the quantity of organic P mineralized to inorganic P.

Leaching of inorganic P can occur in soil but only under certain conditions. Soils that consist largely of quartz sand and soils that are primarily muck and peat are subject to leaching losses of added P fertilizer. This is due to the absence of Al and Fe compounds that are largely responsible for the P adsorption in acid soils. When $AlCl_3$ was added to the two soils, the leaching of added P was almost completely stopped.

The quantity of organic P in soils generally increases with increasing organic C and N; however, the C/P and C/N ratios are more variable among soils that the C/N ratio. Soils also have been characterized by their C/N/P/S ratio, which also variable among soils. On the average, the C/N/P/S ratio in soil is 140:10:1.3:1.3.

Organic P compounds can move in soils to a greater depth than can inorganic P in solution. Several studies have demonstrated appreciable downward movement of P following the field application of manure. Continued application of manure can result in elevated P levels at 2 to 4 ft depths. In contrast, application of the same quantity of P as inorganic fertilizer, P results in much less downward movement of P.

The effect of P availability of other compounds arising from the decomposition of organic matter has received considerable attention. Numerous workers have reported that organic compounds in soil increased P availability by (1) the formation of organio-phosphate complexes that are more easily assimilated by plants. (2) Anion replacement of H_2PO_4 on adsorption sites, and (3) the coating of Fe and Al particles by humus to form a protective cover and thus reduce P adsorption.

Organic anions produced from the decomposition of organic matter also may form stable complexes with Fe and Al thus preventing their reaction with H_2PO_4. These complex ions also may release P previously fixed by Fe and Al by the same mechanism. The anioins that are most effective in replacing H_2PO_4 are citrate.

After general processing and purification statpe, rock phosphate contains between 11.5 and 17.5% total P (27 to 40% P_2O_5). None of the P is water soluble, although the citrate solubility varies from 5 to 17% of the total P rock phosphate can be used directly as a P fertilizers under certain conditions; however, in most situations,

processed from rock phosphate are more cost effective. Dissolution of rock phosphate in soil is mainly influence by its chemical reactivity and soil properties. Soil pH, exchangeable Ca^{2+} and Al^{3+} and OM can affect rock phosphate dissolution.

Rock phosphate solubilities in 2% formic acid 2% citric acid, and nutreal ammonium citrate of more than 65, 40 and 18% respectively, are considered highly reactive and almost as effective as water solubile P under favourable condition. There are indications that 2% formalic acid may be the most reliable of these solubility tests.

Rock phosphate has only limited value to plants, unless finely ground. It must also be thoroughly mixed into the soil and applied at three to five times the P normally provided in conventional water soluble fertilizers.

Finely ground apatitic rock phosphates are effective only on acid soils, with pH 6 or less. On low P acid soil, rock phosphate application may be profitable, but the treated phosphate are generally more economical. Cienerally rock phosphate produces greater crop yields than dose single super phosphate but only when the rock is supplied in quantities that furnish two to three times more P. Rock phosphate has been reported to give better residual effects than super phosphate, but whenever this was so, it was found. That the rates of applied rock phosphate were considerable in excess of those of super phosphate.

Environmental conditions such as warm climates mosts soils, and long growing seasons with increase the effectiveness of rock

phosphate. Rock phosphates in extensively use for plantation crops such as rubber, oil palm, and cacao grown on very acid soils (pH <5) in southest Asia. Ground rock phosphate sometimes used for restoration of low P soil on abandoned farms and on newly broken lands. For these purposes, a heavy initial application in recommended, such as 1,3 tons/a, which may be repeated at 5 to 10 year intervals. Addition of 1000 Ib/a of reactive rock phosphate is a key step in the technology used to rehabilitate tropical savanna land in southeast Asia.

Factors limiting the use of rock phosphate include uncertain agronomic value; inconvenience of handling and applying the fine, dusty material, and relatively low P content compared with triple super phosphate or ammonium phosphate. In situations where the reactivity of rock phosphate is inadequate for immediate crop response and where the P fixation capacity of soil quickly renders soluble P fertilizer unavailable to plants, partially acidulated rock phosphate can increase the water soluble P content and improve the short term crop response to rock phosphate. Partially acidulated rock phosphate produced by treating rock phosphate with 10 to 20% of the quantity of H_2PO_4 used for the manufacture of triple superphosphate or by reacting it with 40 to 50% of the amount of H_2SO_4 normally used in the production of single superphosphate.

In the light of above facts it was thought desirable to undertakes research work in the purview of "Phosphated composting on Soil-Plant relationship" by experimentation with the following objectives:

1. Distribution of forms of inorganic phosphate in some alluvial soil profiles of U.P.

2. Phosphate potential and lime potential of some alluvial soil of U.P.

3. Preparation of Phosphated compost determination of its composition.

4. Application of phospho-compost on paddy, wheat, and red gram, crop for studying plant growth, yield and uptake of NPK nutrients.

CHAPTER - II

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Literature surveyed on the present investigation entitled, "Phosphated Composting on soil-plant relationship" has been presented in the following seven parts :

Part - I

Literature related distribution and forms of P soil profiles.

Part - 2

Literature related to factors which influence the availability of phosphates.

Part - 3

Literature related to phosphated potential and lime potential of soil.

Part - 4

Literature related to transformation of phosphates in soils into different inorganic fractions.

Part - 5

Literature related to phosphate composting with rock phosphate application.

Part - 6

Crop response on application of phosphates with special reference to cereals and legums.

Part - 7

Influence of phosphated composting on soil fertility.

Part - 1- Literature related distribution and forms of P soil profiles.

The major and important group of soils of the U.P. State consist of alluvial soils in the indogangetic basin which occupies more than three fourth of the total land area of the state covering almost the entire central portion. The broad regional soil group of Uttar Pradesh were indicated by Agarwal (1950). A map showing the distribution of major regional soil groups of Uttar Pradesh.

The alluvial soils found in Uttar Pradesh have developed from the sediments deposited by the two great rivers viz. Ganga and Yamuna alongwith their numerous tributaries. The deposits of the gangetic alluvium originated from calcareous parent material, fresh alluvium are accordingly moderate to highly calcareous.

Williams and Saunders (1956) , Mehta and Patel (1963), Pareek and Mathur (1969) and Mehta et al. (1971 reported that the decrease in total - P content in soil takes place along the depth.

Dhir (1956) concluded that Indian soils have total phopshate in the range of 165-1377 ppm with mean value of 474 ppm. He also analysed some samples of Indian soils in relation to their total -P and organic-P content and reported as follows:-

	Total - P (ppm)	Organic-P. (%)
Black soil	419	16.8
Alluvial soil	415	8.8
Forest soil	1268	28.5
Desert soil	240	6.5
Red soil	376	23.3

Climate, vegetation and time have much greater influsence on the forms of P in soils and its availability to crop than on the total amount of soil -P. Chang and Jackson (1957) accorded that amount and forms of soil-P are indication of the stages of weathering in the soils. However as chemical weathering proceeds the Ca-P in the soils is converted first to A1-P then Fe-P and finally to occluded-P. According to Syers and Walker (1969), Williams and Walker (1969) accumulation of non-occluded secondary inorganic-P (NH_4F-P+Ist NaOH-P_ is characteristics of weakly weathered soil.

According to Kanwar and Grewal (1959) Uttar Pradesh soils contain total-P- on an average of 0.08% while Punjab soils found in the range of 279.40-1047.80 ppm with an average value of total-P 496.50 ppm.

Studies on the distribution and form of phosphate in soils provide useful informations in assessing the available-P status and degree of chemical weathering of soil. Characterization of the forms of inorganic phosphate in soils by sequential extraction with acid and

alkaline reagents were initiated by Dean (1938) and modified version of his scheme were used by Ghani (1943) and Williams (1950). Ammonium fluoride was subsequently introduced by Chang and Jackson (1957) to distinguish between Al and Fe-bound-P.

Goel and Agrawal (1960) reported that total phosphorus content of the soils decrease with the maturity of the soils . Highest content of total-P have been found in the clay size fractions and the lowest in the sand size fraction. It has been suggested that the immature soils having maximum concentration of phosphorus in the clay size fractions are better supplier of phosphorus to crops than their mature counterparts havig maximum phosphorus concentration in the sand size fractions.

Raychaudhari and Datta (1964) reported total-P cotent in soils of some states as follows:

Assam	-	0.04 - 0.28%
W.Bengal	-	0.03 - 0.26%
Bihar	-	0.04 - 0.10%
Tamilnadu	-	0.03 - 0.09%
Maharashtra	-	0.23% most of the soil
Andhra Pradesh,	-	0.03 - 0.3%
Karnataka	-	0.03 - 03%
Madhya Pradesh	-	0.03 - 0.3%

Bapat et. al. (1965) studied the form of phosphorus in some Vidharbha soils and found that surface layers of all the profiles were rich in total phopshorus. Inorganic P fraction constituted a significantly high proportion of the total -P. Alluminium occluded-P was found to be in traces. The organic-P content was low and generally decreased with depth. Three profiles containing sufficiently high amounts of free $CaCO_3$ and total CaO were rich in Ca-P forms. Profiles having less of free $CaCO_3$ or CaO were rich in iron and aluminium phosphates. The reductant soluble-P was observed to exceed 25% of the total phosphorus. It was found to be related with sesquioxides or iron content. All the soil profiles were poor in available phosphorus. Significant correlations of available-P with Ca-P have been observed in soils containing more $CaCO_3$ and with Fe-P and Al-P in other soils.

Gupta and Mishra (1968) concluded the inorganic-P fraction, Al-P contribute about 1.45 to 4.72% of total -P in the first layer while Puranik and Bapat (1973) reported contribution of Al-P to the tune of 0.5 to 3.42% of total-P in gangetic alluvium and Black soils of Vidharbha.

Bhandari and Saxena (1968) studied the distribution of organic phosphorus in some soils of Rajasthan and reported that its amount ranged from 10 ppm in the deeper layer to 158 ppm in the surface layer.

Syers et al. (1969) observed that the total-P and organic-P were concentrated in the clay separates of both soils. The amount (ppm) of total and organic-P in the coarse and fine sands was relatively low and the P was largely in the inorganic form. Inspite of the dominance of fine sand, silt and clay contributed the greatest proportion of total -P and organic-P in both profiles, acid extractable P, (Ca-P) apatite contributed two-third of the total inorganic-P in the younger selwyen profile and only onė-fifth in the old templetion profile, indicating a considerable decline in the amount of apatite during approximately 600 years of soil developed.

Deo and Ruhul (1970) fractionated inorganic phosphorus into Al-P, Fe-P and Ca bound-P in calcareous soil profiles of Mewar and found that the well developed, moderately developed and young soils contained on an average 21.5, 28.2 and 39.2 of Ca-P of the total inorganic-P respectively. No definite pattern of Fe-P and Al-P distribution was observed in either of the profiles. Available-P was determined by 4 methods namely Olsen, Brays-I, Morgan and CO_2 saturated water. Correlation study showed that Bray and Morgan extracant removed mostly Al-bound P and not of these extracted significant amounts of Fe-P and Ca bound-P .

Singh and Pathak (1972) fractionated and correlated different forms of soil phosphorus in Bhat soils of district Deoria,. In linear co-rrelation study saloid bound-P has been found to be significantly positively associated with Fe-P (r=0.728) and available P (r = 0.926)

Al-P with Fe-P (r = 0.604) and available -P with Fe-P (r = 0.736) Saloid-bound-P also significantly positively correlated with organic-P (r = 0.523).

Bhan and Shanker (1973) analysed a number of samples and found that U.P. soils ranged from 19.00 to 82.50 mg P/100 g soil. Organic, available, saloid, aluminium, iron and calcium phosphates comprised 32.7, 4.3, 2.9, 8.8, 8.2 and 40.4% of total phosphorus. Most avaiable fractions were saloid and aluminium phosphate showed positive correlation with available phosphorus i.e. r = 0.924 and r = 0.827 respectively. Organic phosphorus showed positive correlation with silt + clay percentage (r = 0.640) where it had negative correlation with pH (r = -0.570). Aluminium and iron phosphate decreased with rise in pH whereas Ca-P showed direct relationship with pH. The significant correlation between iron phosphate and pH and Ca-P and pH were r = -0.705 and r = 0.746 respectively. Ca-P was observed to have declined trend where soils were rich in organic matter content r = 0.568. Iron phosphate showed negative correlation with Ca-P (r=-0.66) which might explain that Ca-P was converted to iron phosphate by chemical weathering.

Bagghi et al. (1974) reported that Ca-P constitutes the highest proportion in soils of Nadia (W.B.) having higher per cent of $CaCO_3$ and higher pH. Fractionation of native phosphate, the Ca-P fraction has strong positive correlation (r = 0.93) with pH. While the other phosphate fractions are negatively correlated with pH of the soils.

Increase or decrease in different phosphate fractions and the different soil pH values are linearly related.

Sacheti and Saxena (1974) observed that saloid-P and Al-P have significant correlation with Olsen's and Morgan's available-P only in sandy loam soils (r = 0.558), (r=0.863), (r=0.531), (r = 0.444), (r = 0.499) respectively with Morgan's-P.

Nath and Deori (1977) presented the different forms of phosphorus in the soils of Arunachal Pradesh. The content of total, Organic, inorganic and available forms of phosphorus in sandy loam soils ranged from 625-2076 ppm, 515-1801 ppm, 75-450 ppm, 1.2-9.2 ppm in sandy clay loam soils ranged from 703-1980 ppm, 568-1745 ppm, 41-390 ppm, 2.4-8.9 ppm and in loam to clay loam soils ranged from 720-3034 ppm, 570-2524 ppm, 110-570 ppm and 1.4-9.3 ppm respectively. The correlation between inorganic-P and available-P in different textural classes of soils studied were found to bear positive significant correlation (r = 0.754) in sandy loam soils (r =0.613) in sandy clay soils and (r = 0.839) in loam to clay loam soils. Again available-P and pH showed negative but significant correlation in sandy loam and sandy clay loam soils r = -0.573 and r = -0.785 respectively, but in loam to clay loams, the correlation was found to be positive but non-significant.

Bhatia and Shankar (1982) studied the phosphorus distribution in central alluvial soils of U.P. and found that inorganic phosphorus

constituted 91.25% of total-P and Ca-P is the predominant form of inorganic-P followed by Fe-P + Al-P. Ca-P positively correlated with total phosphorus (r = 0.836) and negatively with organic-P (r = -0.621) and clay (r = -0.371) . FE-P + Al-P was significantly correlated with total-P (r = 0.861) and negatively correlated with Ca-P (r= -0.515) and clay (r = -0.538).

Debnath and Mandal (1982) reported that Olsen-P have significant positive correlation with Al-P (r= 0.527) and Fe-P (r=0.650). Soil samples of West Bengal fractionated into their NH_4Cl soluble -P, Al-P, Fe-P, Ca-P and Red-P and found in the range of 8.2 - 36.6, 26.4 - 120.4, 57.00 - 132.10, 41.4 to 328.4 and 2.2 - 110 ppm respectively.

Kanwar et al. (1983) analysed 14 soil profiles of Kangra valley of Himachal Pradesh and reported that in Alfisols. amount of total phosphorus decreased with increasing depths whereas in Inceptisols surface layer contained lower amount as compared to sub-surface layer contained lower amount as compared to sub-surface soils. Reductant soluble phosphorus constituted the dominant fraction in Alfisol and Ca-P in Inceptisol.

Sharpley and Smith (1983) observed that cultivation as well as fertilizer P application tended to increase total amount of inorganic -P and decreased org. P in surface horizon (0-300mm) of agriculturally important soils. In general, top soils are found

significantly richer in available-P and all inorganic-P fractions except Ca-P than sub-soils (Reddy et al., 1983).

Tieseen et al. (1983) obtained i the cultivated Bradwell soil that significant amounts (7%) of secondary (NaOH extractable) P forms were associated with high level of labile (Bicarbonate and resin extractable) P. These secondary P forms which were concentrated in the finer particle size fraction (2 ppm) contributed to the P loss during cultivation of the coarse textured Bradwellsoil.

Sharpleyed (1985) determined the amount of phosphorus inorganic and organic pools for three non-calcareous and five calcareous surface soils (0-150 mm) which had been cultivated for atleast 15 years and their virgin analogues, to ascertain it relative pool sizes or soil-P fertility are being changed by cultivation and associated fertilizer application. The soils were found with total -P concentrations ranging from 200-1920 mg/ kg±-1 (approx. 50% inorganic-P) and P-application from 0-90 kg/ha/year P forms in the pools.

Richard et al. (1985) concluded that the content of occluded-P generally increased and the content of non-occluded-P decreased in B horizons. The content of Ca-P tended to decrease a little in A horizon.

Datta and Gupta (1984) reported the soils of Nagaland contain on an average 6.09% Al-P, 9.20 Fe-P, 3.24% Ca-P, 0.99% occluded-Al-P

and 1.20% occluded Fe-P, indicating that the major portion of P was in the organic form. In these soils, content of inorganic P fractions were in the decreasing order :

Fe-P, Al-P, Ca-P Occluded Fe-P Occluded Al-P.

Sharma and Tripathi (1984) studied the indices of phosphorus availability in some Himalayan soils of N.W. India and found that Olsen-P removed most of its P from Al-P fraction (r=0.811) followed by Ca-P (r = 0.471). The inclusion of other forms eg. saloid-P, Fe-P, reductant soluble and organic-P did not alter this situation to any great extent. Bray's procedure derived its P mainly from Al-P followed by Fe-P and Ca-P almost in equal proportion and the extent of variability explained by these fractions was up to 50.5%. The most important source of P for Bray P_2 extractant was Ca-P and about 36.9% variation could be attributed to that in this fraction.

Part - 2 - Literature related to P availability factors.

Verma and Singh (1973) obtained increased yield of wheat by incorporating organic matter, phosphate and urea in soil as a basal dose. Nitrogen and organic matter interaction proved to be beneficial in release of more phosphate from the soil and phosphatic source in alluvium soils. Further Verma (1974) used sunhemp, as a source of organic matter and rock phosphate on production of amino acids in soils and observed in the increase of quantitative as well as qualitative

amino acid synthesis and thereby increasing the phosphate availability and nitrogen content of the soil.

Dhar (1954) reported that addition of organic matter increased the efficiency of rock phosphate and land fertility.

Barber (1958) suggested that the yearly variation in crop response to applied fertilizer phosphorus was due to a variation in the soil phosphorus availability. It was suggested that this variation in availability may be related to differences in the temperature and moisture levels of the soils.

Miller et al. (1961) showed in their experiment that with the application of P and K fertilizers signficantly affected grain yield, P and K contents of soyabean plant. The variation in soyabean yield was accounted for by the variation in the P and K contents of some plant parts. Dry matter yield is also incluenced by different elements (Baown and Legget, 1963). Martin et al. (1965) concluded that there has been a reduction in dry weight yield due to P application.

Sanghi and Sharma (1965) noted a progressive and better nodulation in cluster bean with the application of phosphatic fertilizers and vegetative growth was also enhanced. Increase phosphate uptake by legumes with the increasing level of phosphate fertilization was also observed by Gulati (1968).

Mishra and Singh (1970) reported that grain yield and protein yield in soyabean is affected by phosphate fertilization. Similar

findings were also reported by Gill and Batra (1969). Lakras (1977) and Pawar et al. (1982) considered that the response of phosphorus in soyabean is good in the view of its yield and quality.

Relative efficiency of fertilizers to plants depends on the nature of the fertilzer. A review of experimental work carried out in India and abroad to evaluate the relative efficiencies of citrate and water soluble phosphatic sources was revealed by Dhua (1970) as following:

(i) Response in early stages of growth is better with water soluble rather than with citrate soluble phosphatic sources but in final yield such differences never persists.

(ii) In acidic soils water insoluble sources proved as good as water soluble sources whereas in alkaline soils although the water soluble sources were slightly superior. The differences in yield were only marginal.

(iii) The residual effect of both citrate and water soluble sources were found to be the same and in some cases citrate soluble sources proved superior to water soluble sources in this respect.

(iv) The size of granules of citrate and water soluble sources also influence greatly to crop response depending on pH on the soils.

Dhawan and Sethi (1970) observed that in case of soil where P is bounded by calcium and magnesium EDTA is a better chelating

agent and where phosphorus is bounded by iron and aluminium, aluminium is a better chelatig agent.

Blair and Miller (1971) found that by the application of ammonium sulphate with monocalcium phosphate increased fertilizer - P uptake when compared to MCP alone on soils of pH 8.2, 7.4 and 5.5.

Mandal and Mandal (1973) reported that the application of organic matter greatly reduced the fixation of iron phosphate in all the soil and increase availability of P in soil. Application of lime also significantly lowered the fixation as Fe-P.

Chaudhari et al. (1974) resulted in his experiment that Ca-P is a source of P availability to Jowar, cowpea and Urd crops. Significant correlation have been observed between P uptake and inorganic-P fractions.

Meelu et al. (1977) reported that the response of wheat to P source was directly related to the water soluble -P content in the fertilizer material.

Varadan et al. (1977) compared P fertilizers (Rock phosphate, Basic slag, Dicalcium phosphate and superphosphate) and observed that these fertilizers did not differ significantly in their effect on grain yield of ragi.

Katyal (1978) reported that delaying of P application beyond 14 days on a P-deficient black soil after transplanting reduced the grain

yield and increased the duration of maturity, the effect being more marked in the dry season that in the wet one.

Akbari et al. (1981) showed in their experiment that availability of P (Olsen extractable P) decreased with time up to a certain limit but it showed increasing trend thereafter. The availability of phosphorus was found to increase significantly with the increasing level of P and moisture.

Chahal et al. (1982) suggested that continuous applicatoin of phosphatic fertilizers (DAP, TSP, NP) caused a decrease in soil pH and increase in organic carbon content. Available -P status of soil decreased in control plots but increased from 8.0 to 26.2 kg/ha in plot receiving 60 kg P_2O_5/ha.

Chakravorti et al. (1982) suggested to apply all the P as basal at puddling in the event of difficulties in obtaining fertilizer in time. Top dressing of P may be done within 10-30 days after transplanting to avoid the risk of low recovery of applied P from soil.

Soil was classified in three fertility classes namely low, medium and high, containing less than 12.4, 12.4-22.4 and above 22.4 P kg/ha. Bishoni and Singh (1982) reported significant increase in grain and straw yield of moong upto 20 ppm on low P upto 15 ppm medium P and only to 10 ppm P_2O_5 on high P soil.

The fraction of phosphorus which is accessible to plants is known as "available" and this amount of P is generally extracted by

different extractants. Most commonly following reagents are used by the methods currently used is referred by ISMA (1982).

— Sodium biocarbonate 0.5 N, pH 8.5 (Olsen method) especially for alkaline and calcareous soils.

— Ammonium fluoride 0.03 N+HCl 0.025 N (Bray and Kurz P1) or HCl 0.1 N(Bray and Kurz P_2) for acid and neutral soils.

— Ammonium acetate pH 4.65.

— Distilled water, one extraction (P_w) two extractions (Ferrari-Marimpietri).

— Ammonium lactate 0.1 N acetic acid 0.4 N, pH 3.75 (Egner-Riehm) CAL (Calcium ammonium Lactate), DL (Double lactate).

— Ammonium acetate 10%, acetic acid 3%, pH 4.8 (Morgan) or pH 3 (Barbier Morgan).

— Sulphuric acid 0.2 N (Truog) for calcareous soils.

— Weak double acid (HCl 0.05 N + H_2SO_4 0.025 N).

— CO_2 saturated water (Dirks scheffer)

— Citric acid 2% pH 2 (Dyer).

— Neutral ammonium oxalate 0.2N (Joret Hebert).

Part - 3 – Literature related to P - potential & lime potential of soil.

The inadequacy of using a single parameter to describe the phopsphate status of soils has been evident for some time. Wiklander (1950) discussed phosphate status in term of capacity, intensity and 'ease of defixation' (Kinetic) components but his concept are not easy to translate directly into term of readily measured experimental quantities.

Schofield (1955) emphasized the importance of adding an intensity factor to the more frequently considered capacity factors and his concept of phosphate potential as developed by Aslying has provided a practical basis for measuring such a factor (Aslyng, 1954 and Schofield, 1955).

Most of the conventional extraction procedures for the determination of soil phosphate give measures of capacity factors, although some of those which involve short periods of extraction or successive extractions are also dependent on the rate of release of phosphate from the soil under the influence of the extracting agent used. Leaching technique was used by Fried et al. (1957) to measure the rate of phosphate release from soils.

The supply of phosphate to the plants under most situations is believed to be a function of four primary factors viz. capacity, rate, intensity and diffusion. Of these the capacity factor measures the

ability of the soil to replenish the 'nutrient pool' and is given by the ratio Q/I. Where Q is the mobile fraction known as the quantity factor and I is the intensity factor. Phosphate potential measures this intensity factor.

The supply of phosphate to the plant has been presented by Larsen (1964) as follows:

$$\text{P soil} \underset{K_2}{\overset{K_1}{\rightleftharpoons}} \text{P solution (Near soil surface)}$$

$$\Big| \quad \text{Diffusion} \quad \Big|$$

$$\text{P solution (Near root)} \underset{K_4}{\overset{K_3}{\rightleftharpoons}} \text{P plant.}$$

For plants in active vegetative growth, K_4 is likely to be negligible and the rate of uptake from solution, K_3 is likely to be limiting only at high phosphate concentratios. Therefore, for most situations, the system simplifies to four primary factors : capacity (P-soil), rate (K_1 / K_2) , intensity (P-solution) and diffusion.

In the absence of a plant root, the concentration of phosphate in soil solution is governed by a dynamic equilibrium between the solid and solution phases. In which phosphate continually dissolve from soil and is re-sorbed by the solid phase. In the presence of a plant root which is absorbing phosphate from the soil solution this equilibrium will be upset and if the phosphate concentration in the solution is reduced sufficiently the rate of phosphate uptake by the plant will be limited.

Loganathan and Kishnamoorthy (1976) studied the influence of different $CaCl_2$ concentrations on different soils (Black, Red, Alluvial and Laterite) and found that various concentrations (0.002M, 0.01M, 0.05M) did not bring about significant variation in lime potential values, although considerable variation in lime potential values of the different soils was observed. Lime potential could be found out by deducting 1.14 from pH which is an easily determinable property of a soil.

Padmawati and Narasimham (1978) obtained the relationship between lime potential and phosphate potential of alluvial soils of Andhra Pradesh based on solubility product of known calcium phosphate, that dicalcium phosphate was prominent in most of these soils with admixture of octacalcium phosphate in a few others. Formation of hydroxy apatite in any of the soil was ruled out.

Abbas et al. (1982) studied phosphate potential and lime potential and their relationship against the calculated solubility product data of calcium phosphates of some alluvial soils of U.P. and observed that most of the soils were predominant in dicalcium phosphate and mixture of octocalcium phosphate. There was no chance of formation of hydroxy apatite in any of the soil.

Part - 4 – Literature related to P-transformation in soils into inorgnic P fractions.

According to Mitsui (1960) available-P is increased in water logged condition mainly due to hydrolysis of Al-P and Fe-P and also due to increase in solubility of Fe-P.

A number of research workers have indicated, beneficial effect of submergence including better nutrient availability. Annual report of IARI (1963) McKeogue and Cline (1963) organic matter treatment reduced the transformation of added -P as Fe-P in all the soils. The decomposition of added organic matter might have created an intense anaerobic condition causing reduction of ferric to ferrous compounds which is responsible for the transformation as Fe-P considerably. The transformation of added P into different fractions in laterite, recent alluvial and alluvial soils found as in descending orders : Al-P > Fe -P > Ca-P, Ca-P > Al-P > Fe-P and Ca-P > Fe-P > Al-P respectively.

Chiang (1965) studied the residue soil of paddy and observed that the availability of Al-P, Fe-P and organic -P become lower as the soil is more acid while that of Ca-P has the reverse trend of becoming higher under the same condition. Occluded-P is unavailable to rice plant.

Abbas et al. (1967) working with soils from acid to alkaline pH ranges found that P^{32} tagged fertilizers got coverted to Fe-P and Al-P, these being dominant in acid to neutral soils while in the soils having higher pH about 50% of the added P was recovered in the Ca-P fraction.

Chiang (1968) considered the cereals particularly paddy affects mainly through chelation of iron and aluminium cations with

exudates of roots and in water logged condition it may also mobilize phosphorus of Fe-P and Al-Phosphate through the action of evolved H_2 and H_2S gases and help their adsorption by plant.

It is generally accepted that under water logged conditions, aluminium bound phosphate increases and reductant soluble iron phosphate decreases. Mahapatra et. al (1969) and Chang and Chu (1961) observed that under waterlogged condition the added phosphate is mostly fixed as iron phosphate.

Patrick et al. (1974) using P^{32} tagged $AlPO_4.2H_2O$, Fe-$PO_4.2H_2O$ and NaH_2PO_4 observed that most of the applied P was recovered in the Al-P and Fe-P fractions.

Mandal and Khan (1976) studied the treatments of applied P in their different fractions in air dried submerged and field capacity level. The results showed that moist treatment could maintain a higher amount of added P in the water soluble saloid bound and Traug's available form. The transformation into Fe-P was lower under submerged treatment as compared to that in the air dried and mosit treatments. Transformation into red-Fe-P found was very small and as such no effect of the moisture treatment could be observed.

Mandal and Khan (1977) studied the transformation of fixed -P when the soils were rewaterlogged and observed that Al-P did not changed but Fe-P recorded a decrease immediately after

rewaterlogging the soil. The fixed Ca-P recorded an increase in rewaterlogged soil.

Singh and Ram (1977) reeported that increase in available-P in the red soil was related mainly to decrease in FE-P and Ca-P concentrations while in Karail soil it was related to decrease in Al-P and Ca-P. The decrease in available-P was due to reformation of insoluble Fe-P and Ca-P in red soil and Ca-P and Al-P in Karail soil.

Abbas (1980) found in his laboratory experiment using alluvial soil highest increase in Al-P content. However, with the progress of incubation there was a graded decrease in Al-P content and an increase in Fe-P content.

Das et al. (1982) studied the availability of soil and fertilizer-P and their transformation into various inorganic-P fractions under flooded condition and showed, Al-P cotent in the acid and red loam soils was in decreasing order of S.P., DCP, ANP, TCP and KMP. The Fe-P content in the acid soil was in range 44-49 ppm for different fertilizers. Flooding enhanced the movement of all three P sources to the Fe-P fraction at the expense of Al-P with an increase in the recovery of added P in the Al-P and Fe-P fractions. There was a corresponding decrease in Ca-P.

Singh and Dixit (1983) reported that on incubation of native-P, saloid bound-P, Al and Fe-P tended to increase while Ca-P decreased in comparison to their original values. The various P fractions increased at different incubation periods more so at higher level.

Nad and Goswami (1984) observed from continuous application of phosphatic fertilizers to a rice wheat cropping sequence for over ten seasons resulted in an increase in soil phosphorus status particularly in the Al-P and Fe-P fractions. There was however no consistent relation between these fractions and available -P (Olsen-P) in the soil.

Part - 5– Literature related to phospho composting.

Engelstad et al. (1979) have observed a close relationship was found between first crop rice yield response to applied P and citrate solubility, in a series of phosphate rock representing the theoretical range in this parameter. Greenhouse and field data showed quite similar results in this respect. For the second crop, however the relationship between yield response and initial citrate solubility of the phosphate rock was rather poor.

Mathur (1980) worked in compost charged with varying levels of Mussoorie rock phosphate with and without pyrite at different time intervals showed that after 160 days of incubation the release of citric acid and water soluble P was significantly higher with high dose of phosphates as compared to lower dose. In the earlier stages of composting the release of P was greater from the compost charged with rock phosphate alone than that with rock phosphate and pyrite but after 190 days the release was highest from compost charged with lower dose of pyrite. The release of P was only a small fraction of the

total P added. Addition of lower doses of P or pyrite significantly increased the N content of chraged compost.

Mishra (1982) studied the phosphate enriched compost containing 3.13% P was prepared by composting cattle dung and farm waste with Mussoorie rock phosphate. The phosphate rich phosphocompost had low water soluble and bicarbonate soluble P but had 50% of total P in citric acid soluble form. The phosphate released from rock phosphate during composting did not exist freely but was refixed with excess calcium present in the system. The phosphocompost was found to be comparable to single super-phosphate in field trials with green gram (Vigna radiata) and wheat (Triatieum aestivum) for yield and P-uptake.

Singh (1983) Studied the indigenous low grade rock phosphate (RP) was solubilised by composting with pearl millet Boobla (pmb) in the presence of nitrogen molasses and pyrite. The solubilization of rock phosphate was rapid upto 15 days in pmb + M + RP and reached a maximum of 60% in 120 days of composting. Molasses had on beneficial effect on solubilisation while pyrites decreased it drastically in spite of decreasing the pH and increasing the citric-soluble P of the composting material.

Mathur (1983) observed charging farm compost with mussoorie rock phosphate with and without pyrite increased the citrate soluble P. Much of inorganic P was changed into organic

form during composting. Different inorganic phosphorus fractions were found in the decreasig order of abundance as Ca-P occluded Fe-P, Fe-P, Al-P and occuded Al-P. Incorporation of rock phosphate also improved the quality of compost by increasing the contents of nitrogen, calcium, magnesium, and micronutrients.

Mishra (1984) studied the effect of Mussoorie rock phosphate inriched compost, 'phosphocomposts' (Containing 8.0 wt.% P_2O_5) on yield and P uptake in red gram (Cajanus cajan (L.) Mill sp.). The phosphocompost was superior to single superphosphate in its effects on yield. P and N uptake and nitrogenase activity of the nodules. Humic acid solubilized the rock phosphate and was considered one of the factors responsible for better availability of phosphate on composting.

Bangar and Yadav (1985) have observed phosphorus from Mussoorie rock phosphate was solubilized and transformed into available forms when Mussoori Rock phosphate was incorporated during composting of organic wastes. Clusterbean and red gram utilized phosphorus efficiently from the phosphorus enriched compost containing 3.1% P when added in the soil of pH 7.6 to 7.8 . The solubilization of phosphorus during composting has been attributed to the formation of humic substances.

Singh (1985) worked in phospho-compost which was prepared by composting varying amounts of low grade rock phosphate with

mixture of different kinds of farm waste. All the levels of rock phosphate incorpiration increased the loss of organic matter during the time of composting but maximum loss (41.1%) was found with the mixing of 1 kg rock phosphate per 3.65 kg waste on the dry weight basis. The water soluble P_2O_5 decreased with increasing the amount of rock phosphate while organic and citrate soluble P_2O_5 increased significantly. The higher level of rock phosphate (2.5 kg per 3.65 kg dry waste) reduced the concentration of both organic and citrate soluble P. Phosphocompost prepared by enrichment with 1 kg rock phosphate per 3.65 kg waste was found to be as good as single superphosphate in micro plot field experiments taking moong bean and wheat as the test crops.

Mishra and Bangar (1986) studied the transformation of phosphorus that took place with the addition of Mussoorie rock phosphate during composting of organic wastes. The effect of P-enriched compost on crop yields and the mechanism of transformation have been also studied. It was found that apatite phosphorus was solubilized during compsoting but the water souble phosphorus was immediately converted to citric acid souble forms which could presumably be utilized by the plants. The phosphorus enriched compost has been found to be comparable to single superphosphate in crop response and phosphorus uptake in soil having a pH between 7 and 8.

Bangar et al. (1989) observed a nutrient rich compost from paddy straw was prepared using urea and Mussoorie rock phosphate for N and P enrichment respectively. Inorganic N was partly conserved in the compost by the addition of pyrite citric acid soluble P also increased with the addition of pyrite. Compost containing about 1.6% total N and 3.3% to total P was found to be a good source of P for a wheat crop and also supplied a significant amount of N to the plants.

Susham et al. (1993) noted in a field trial which was taken up during wet season of 1989 with different source of Phosphate viz. superphosphate, Mussoorie rock phosphate, partially acidulated rock phosphate and Mussoorie rock phosphate with fungi. Grain yield of rice was highest with Mussoorie rock phosphate fungi in conjunction with either green manure or farmyard manure. The fertilizer use efficiency was highest for the combination of Mussoorie rock phosphate fungi plus green manure.

Tomar and Sharma (1997) studied the Mussoorie rock phosphate and triple superphosphate (TSP) which were incubated with iron pyrite and cattle dung for 15 weeks and then were applied to a sodic soil to study the effect on the availability of Zn to the wheat crop. Pyrite decreased the Zn concentration in the wheat shoots owing to dilution effect and the antagonistic relationship with Fe, whereas manure and phosphates increased shoot and Zn concentration. Uptake of Zn by wheat increased with the application

of pyrite manure and phosphates owing to the decrease in pH and exchangeable sodium percentage of soil and better plant growth. Unincubated TSP was more effective then unincubated MRP, while both the sources were at par when applied after incubation with pyrite and /or manure.

Dhliwayo et al. (1997) studied the composting Dorowa rock phosphate, gypsum, single superphosphate and compound fertilizer with cattle manure or curing heaps simultaneously enhanced the residual agronomic effectiveness of both Dorowa rock phosphate based phosphate fertilizer materials and cattle manure by an average of 82% (range, 72.999%) for groundnut, and 96% (range 73-116%) for stover yields, compared with the control. The residual agronomic effectiveness of single superphosphate was found to be 37% for groundnut seed and 38% for groundnut haulm yield compared with fertilizers. Compound fertilizer had a residual effectiveness of 32% for groundnut seed and 34% for haulm yields compound with on fertilizers. Partial acidulation, pelleting compaction of Dorowa phosphate rock are alternative low cost improvement processes that also enhance the residual agronomic effectiveness of Dorowa phosphate rock. Composting partially acidulated, pelletized and compacted Dorowa phosphate rock based P fertilizer materials with cattle manure is considered a feasible technology for small holder farmers who live around Dorow phosphate Mine in Zinbabwe.

Niranjan and Singh (1998) Studied in a field experiment which was carried out to compare the different phosphate carriers on paddy (var. Saket-4) using 10% , 30% and 50% PAPR with two levels 30 and 60 kg P_2O_5 ha^{-1}.

Application of different phosphorus carriers significantly increased grain and straw yield and phosphorus uptake. Maximum yield was recorded when 50% PAPR was the phosphorus source, showing the value 38.62 Q. ha^{-1}. Response of phosphorus was more pronounced with increasing phosphorus levels. Among different partially acidulated phosphate rock tested, the performance of PAPR (50%) was the best.

Verma (1998) observed that the nutrients required for crop growth are supplied in balanced proportion through soil environment by judicious application of organic matter and phosphates. Researches of Dhar and his associates (1968) have proved that the crop yield and its quality are improved to a great extent by organic matter and in phosphate, incorporation into soil. The residual effect of the mixture of organic matter and phosphate application on the second and third subsequent crop yield was also significant as compared to different NPK combinations.

Narayanasamy and Biswas (1998) reported that the consumption of fertilizers in India is only 76.8 kg N + P_2O_5 + K_2O per ha as against the world average of 89.0 kg. ha^{-1}. The situation of phosphatic fertilizers is even worse because of price decontrol in

1992. Phosphate rock (PR) resorces in India, which is about 200 million tonnes, are assessed in this article in terms of their basic characteristics and prospects of using PR for direct application. The basic characteristics of PRs viz. their origin, crystallography, chemical composition, and mineralogical composition which affect the reactivity are presented and discussed. Agronomic suitability of indigenous PRs for direct application depend on particle size of PR, nature of crops, soil properties like pH, available P status and P-fixing capacity, CEC organic matter and moisture content, and methods, techniques, time and dose of application, The effectiveness of low grade PRs in natural to alkaline soil can be increased substantially by mixing it with superphosphate, by converting it as partially acidulated materials, by introducing phospphate solubilising microbes by mxing with pyrites and FYM constraints in increasing production of PRs and future needs of R and D in this area and also indicated.

Santhy (1999) studied in apotex periment which was conducted to evaluate the suitability of acidulated rock phosphate for growing rice in a red sandy clay loam soil with different source of phosphorus in order to supply 50 kg P_2O_5/ha. As the degree of acidulation of rock phosphate increased the amount of water and citrate soluble phosphorus contents increased. Phosphorus availability increased with phosphoric acid acidulated rock phosphate then with sulphuric acid.

Manna and Ganguly (2000) reported that the low organic matter coupled with low native soil phosphorus is a major constraint limiting the productivity of vertisols and Indo-gangetic alluvium. Their efficient management is indispensable for the sustainability of different cropping system. Information available on the effect of mixing rock phosphate with different quality of organic sources and their field application are meagre. Different wastes of farm and city garbage either along or in conjunction with cheap surce of mining elements such as rock phosphate and pyrites wre used for compost making. Sufficient bio inoculum were also used to shorten the usual period of composting form 6 months at 3-4 months and to improve the quality of mineral enriched compost substantially compared to conventional compost. Different field experiment showed that mineral enriched compost at 10 t/ha^{-1} performed similar to single superphosphate applied at 30, 40 and 50 kg P_2O_5/ha in terms of grain yield of green gram under alluvial soil. Similarly, continuous application of mineral enriched compost at 5 t/ha yielded soyabean grain at par with recommended doses of mineral fertilizer. In this paper the technique of preparation of mineral enriched compost and its effect on crop production, different cropping system and soil environmental and soil chemicla and biological qualities have been highlighted.

Ayyer and Akolkar (2000) studied and carried out experiment to quantify the gaseous components evolved during the digestion of

rock phosphate with weak nitric acid at eleated temperature. Rock phosphate samples from a variety of sources have been studied for comparison purpose. The data indicates in a comparative manner the levels of components like NO_3, fluoride and chloride that are evolved as vapour durig the rock digestion and can be expected to affect the equipment they come in contact within the vapour phase.

Smolders et al. (2001) determined in a laboratory experiment, different iron salts (Fe Cl_2, $FeCl_3$, $FeSO_4$) and Fe_2O_3 which were added to a phosphate enriched silty loam sediment in order to study their effect on phosphate mobilization. Phosphate concentration in sediment pore chlorides, however resulted in a strong decrease of phosphate levels in sediment pore water. A similar but less pronounced effect was caused by the addition of iron as iron (II) sulfate. Sulfate appears to counteract the imobilization of phosphate brought about by iron (II). Phosphate release from the sediment appeared to be determined by the iron. Phosphate ratio in the sediment pore water. The addition of Fe_2O_3 barely affected the phosphate release from the sediment whereas the additon of iron salts was effective in preventing phosphate release. Increased amount of iron added to the sediment resulted in a decreased phosphate release.

Rayes, et al. (2001) have worked in venezuelan phosphate rock (PRs) apatite deposits from Monte Fresco and Navay areas, and two minerals. Florida apatite and Utah variscite were used to investigate

phosphate solubilization by the wild type strain IR-94 MFI of penicillium rugulosum initially selected for its high mineral phosphate activity (MPs^{+})and two of its mutants Mps^{++} and Mps^{-}. In liquid cutures, the three fungal strains showed better growth on the Navay PR than on Monte Fresco PRs. The utah variscite was the best phosphorus (P) source for the growth of the wild type and the Mps^{++} mutant. Solubilization of the various P sources by the wild type IR-94 MFI and the Mps^{++} mutant resulted mostly from the action of organic acid. Citric acid seemed to be more active agent for the solubilization of the Utah variseite while gluconic acid appeared to be responsible for the solubilization of the florida apatite and the Monte Fresco PR. Both organic acids are likely involved in the solubilization of the Navay PR. The Mps mutant did not produce any organic acid when grown on all the P source used.

Part - 6– Crops response on application of phosphates.

Ray and Diest (1979) have worked in wheat, paspalum plicatulum, maize, molasses grass, soyabean and buckwheat were compared for their abilities to utilize P from superphosphate, a calcined aluminium phosphate and 4 rock phosphate. Buck wheat showed an exceptional behaviour in that it could utilize all phosphates. For the other spp. only the calcined aluminium phosphate and 1 rock phosphate had significant fertilizing value. Their efficiencies relative to superphosphate were 0.45 and 0.11 for wheat 0.73 and 0.43 for P. plicatulum, 0.50 and 0.37 for maize 0.46

and 0.42 for molasses grass, 0.28 and 0.38 for soyabean and 0.72 and 1.08 for buck wheat, resp. for superphosphate, calcined aluminium phosphate and hyperphosphate, a relationship between soil acidity and P. uptake was found Soil pH in its turn was negatively related to the ratio of total equivalents of cations : anions absorbed, consequently, P plant spp. on soil pH could also explain the difference in uptake of P from sparingly soluble phosphates. The relative eficiencies of calcined aluminium phsphate and hyperphosphate for the various plant spp. were closely related to the ratio of total cations : anions absorbed by these plants.

Aspiolea et al. (1986) studied the decumbens growing on a ferrallitic soil in cuba received (a) no fertilizer or 2001 kg / ha P_2O_5 per year as (b) triple phosphate (c) single super phosphate or (d) rock phosphate over 3 years. An av. of 7 cuts were made at 6-7 week intervals each selason to give total DM yields of 58.2 , 70.6,83.06, and 69.4 t/ha with (a) , (b), (c) and (d) resp. soil, P_2O_5 was about 2 mg/100 g at the start of the experiment and 2, 9 8 and 28 mg/100 g with (a), (b), (c), (d) and respectively issue P content at the end of the 1st year was 0.24-0.25% however SO_4 content was 0.08, 0.11, 0.23 and 0.09%, respectively, in (a), (b) , (c) and (d) . Plant S content had a quadratic relationship with DM yield, suggesting a critical level of 0.13- 0.21% SO_4 and underlyining the importance of S fertilizer.

Mendora (1988) observed that the extractable phosphate values in soil were affected by the soil phosphate buffer capacity, soil pH and

concentratoin of the extracting solution. Values obtained by Bray and Olsens methods were more highly correlated with P uptake by plants than were those obtained by Bray and colwell's methods which extracted more P then that extracted by plants.

Morel and Fardeau (1990) studied the agronomic effectiveness of P fertilizer was evaluated using the quantities, Pf. of phosphorus taken up by Lolium perenne grown on 14 soil in pot cultures. The Pf quantities were determined using P^{32} labelled fertilizers. Data were analysed using a new concept : the Isotopic relative agronomic effectiveness (TRAF). The IRAF value was defined as the ratio of the Pf quantity taken up by a crops, of a tested fertilizer over the Pf quantity, taken by up a crop of fertilizer used as standard. Diammonium Phosphate (DAP) was used as standard P fertilizer and two rock phosphate, a North Carolina rock phosphate (I) and a calcium-Iron - aluminium phosphate (II), were tested. As a linear relationshp between Pf (I) quantities and Pf (DAP) quantities was obtained with $v^2 = 0.95$, when the application rates increased from 15 mg P/kg soil to 200 mg P/kg soil, it is concluded that IRAF value for a given fertilizer, other than the standard fertilizer, could be determined with a single rate of application. For soil pH in the range 4.7 to 8.2 IRAFI is related to soil pH by a curvilinear relationship: log IRAEI = - (0.44) pH + 4.05 with $v^2 = 0.89$.

Carlsson et al. (1991) studied the new pilot plant for combined biological phosphorus and nitrogen reoval was started up at sjolunda

sewage treatment plant in Malmo. So far (May 1991) the pilot plant studies has been focussed on simultaneous phosphate uptake and denitrification. Results elearly showed that it is possible to induce phosphate accumulating bacteria , under realistic circumstances, to use nitrate instead of oxygen for phosphate uptake.

Sattar and Gaur (1991) studied the response of wheat (var. BD2204) to vA-mycorrhiza and four phosphate dissolving microorganism (Aspergillus awamori, A. niger, Pseudomonas striata and Bacillus pulvifaciens) were investigated in presence and absence of rock phosphate and superphosphate at 0.03 and 60 kg/P_2O_5/ha in a 4 replication pot culture experiment. In case of grain and straw production. A. Awamori performed better amongst the cultures, the increase being 22 and 17% over uninoculated control respectively. P. striata recorded 41% higher Phosphate uptake. When applied with C. fasciculatus. The combined application of rock phosphate and super phosphate at 30 kg P_2O_5/ha each with FYM yielded 131% more grain, 79% more straw and 183% more phosphate uptake than their respective controls. The grain was further increased when microbial inoculants were used with fertilizer treatment. Cultures with higher dose of super phosphate recorded reduced effect on yield (13-40%) and P. uptake (6-38%) . Mixed inoculation was also found inferior to other cultural treatments.

Singh and Kapoor (1992) observed that the five selected isolated of phosphate solubilizing bacteria were evaluated for the

solubilization of tricalcium phosphate in pot experiments with a sandy soil and mungbean (vigna radiata) as a test crop. solubilization was dependent on the pH of the medium. Phosphate remained in the soluble form while the pH was low. As the pH increased free calcium reacted with soluble phosphorus and was reconverted into insoluble forms. The inoculation of mungbean seeds with phosphate solubilizing bacteria led to an increase in dry matter production and phosphate uptake. The effect of inoculation was more pronounced in the presence of Mussoorie rock phosphate . The response was lower than that obtained with single superphosphate as phosphate source.

Sasai (1992) reported that the field tests on maize, soyabean, tomato, carrot and Arctium lappa the application of phosphorus fertilizers increased shoot DW, increased shoot phosphourus content after the second cropping days (86 days after sowing) and decreased mycorrhizal infection rate to varying degrees. Mycorrhizal spore number in rhizosphere soil (soyabean, tomato and maize) was much higher in soil without added phosphorus. It is concluded that VAM fungi promote phosphate uptake in low phosphate soil during the early stages of plant growth.

Hoffland (1992) suggested that the phosphorus defficient rape plants appear to acidity part of their rhizosphere by exudating malic and citric acid. A simulatoin model was used to evaluate the effect of measured exudation rates on phosphate uptake extended to include both the effect of ion uptake and exudation uptake, extended to

include both the effect of ion uptake and exudation ion rhizosphere pH and the effect of rhizosphere pH on the solubilization of rock phosphate. Only the youngest zones of the root system were assumed to exude organic acid. The transport of protons releaed by organic acid was described by mass flow and diffusion. An experimentally determined relation was used describing pH and phosphate concentration in the soil solution as a function of total soil acid concentration. Model parameters were determined in experiments on organic acid exudation and on the uptake of phosphate by rape from a mixture of quartz sand and rock phosphate. Results based on simulation calculations indicated that the exudation rates measured in rape plants deficient in phosphorus can provide the root with more phosphate than actually taken up. Presence of root hairs enhanced the effect of organic acid exudation on calculated phosphate uptake. However, increased of root hair length without exudation as an alternative strategy to increase phosphate uptake from rock phosphate appeared to be less effective than exudation of organic acid.

Bolland and Kumar (1993) determined the Pi, colwell, Brayt, Calcium acetate lactate (CAL) and Truog phosphorus soil test reagents were assessed in to field experiments on lateritic soils in western Australia that has been fertilized four years previously (1984) with triple superphosphate, North carolina rock phosphate queensland rock phosphate, and in one experiment, calciphos. Soil

samples to measure soil P test were collected in February 1987. Soil P test was related to seed (grain) yields measured later in 1987. Different crop species were grown on different sections of the same plot at each silt. The species were lupins, barley and oats at one silt, and lupins, oats, triticale and rapeseed at the other silt. For each reagent, the soil phosphate test calibration which is the relationship between yield, and soil phosphate test, generally differed for different plant species and for different fertilizer types. Variations in soil P test required to produce hold the maximum yield of each species at each silt were test for the CAL reagent followed by the Colwell reagent.

Ming Gang and Zhang (1995) studied the depletion rate of phosphate in the soil root interface zone increased along with growth and phosphate uptake of wheat or maize, which indicated that the phosphate distribution in soil near the root surface agreed well with the phosphate movement in rhizosphere and phosphate uptake by plant. The relative accumulation zone of phosphate within 0.5 mm 19 part from the root surface developed at the 15th day or so after cultivating wheat or maize since the root phosphate secretion increased gradually in this stage. The phosphate distribution in the soil-root interface zone against the growing time (t) and the distance from the root plane (x) could be described by the non-linear regression equation with the third powers of x and t

Part - 7– Influence of phosphated composting on soil fertility.

Chien and Hammond (1978) have determined a simple, chemical method which does not involve shakig the sample and which employs on H-resin was used to evaluate the suitability of two granulated phosphate rock over the range of granule sizes. Solubility decreased drastically as the granule size increased from the average diameter of 0.05 mm to 1.00 mm. The conventional citrate extraction method which involves shaking the sample cannot be used in this case because the granules disintegrated upon being shaken and this results in essentially the same solubility value being recorded for all samples regardless of the granule size. A highly significant linear relationship between the dry matter yield of corn (Zea mays) (6 weeks in green house and the solubility of the granulated rock suggests that the proposed H-resin method can be used to predict the potential of granulated phosphate rock for direct application.

Venkateswarlu et al. (1984) studied that the populatoin of phosphate soublizing microorganism was generally low in desertic soil (Aridisols) possibly due to the low level of organic matter and high temperature regime. Bacillus cereus, Pseudomonas flurescens, Penicillium pinophillum and Aspergillus niger were some of the predominant phosphorus solubilizers found in most of the soil. In vitro evaluation of these cultures indicated that fungi were more efficient than bacteria in phosphorus solubilization phosphorus release by all the organism was associated with the production of

organic acid in the medium. The solubilizing effect of A. niger was progressively enhanced by increasing glucose concentration (0.5 to 2.0%) in the medium, but with rock phosphate such enhancement was not observed beyond 0.25%.

Syers and Mackay (1986) suggested that the reactions of Schura phosphate rock (SPR) and Single Super Phosphate (SSP) were investigated in an incubation study using contrasting soils over 90 days. The rate and extent of dissolution of SPR measured by a single extraction with 0.5 M NaOH, increased as the phosphate (P) - sorption capacity of the soils increased. In contrast, the initial disssolution of SSP was independent of soil type. Whereas the amounts of water and Olsen extractable P in soil to which SSP was added declined from the time of application, the amount of Olsen and Bray extractable P in soils to which SPR was added initially increased, with both P source, the amount of extractable P decreased as P sorption capacity increased. In a glass house experiment a poor relationship ($r = 0.051$) was found between P uptake by ryegrass from soil to which SPR was added and the extent of dissolution at 90 days. In contrast a very good relationship was found between P uptake by ryegrass and Bray extractable P in soil to which SPR was added. It is important to distinguish between those soil properties that promote the dissolution of a PR and those that control the subsequent amounts of plant available P in soil.

Weatherley et al. (1988) reported that the effectiveness of calciphos calcined rock phosphate from christmas Island, Queensland rock phosphate (low carbonate substituted apatite (QRPI) and granular North Carolina rock phosphate (high carbonate substituted apatite (NCRP) were compared with the effectiveness of monocalcium phosphate (MCP) fertilizers in pot and field experiments.

Fritseh and Weerner (1988) have studied the long term field experiment, chemically treated sewage sludge led to lower phosphate uptake by plants in a root crop / cereal rotation, compared to mineral fertilizers of FYM. The solubility of soil phosphate accumulated after applying sewage sludge was low in relation to phosphate supply. High rates of all amendments increased lactate soluble phosphate but in the case of sludge, phosphate concentraton in the soil solution decreased. Sewage sludge thus led to an increase in the quantity. intensity ratio of soil phosphate; P sorption capacity of the soil increased due to accumulation of oxalate soluble Fe, as a result of sludge treatment with $Fe\ Cl_3$ to remove P from effluent.

Reichert et al. (1989) observed that the phosphate desorption and the releae of phosphate from Al- phosphate by organic acid was show to follow the result of direct competition of anions, being dependent on the type and concentration of the anion and on the specific surface area of the solid particle. The experiments were carried out using boehmite and bayerite and a range of organic acid.

Zaharah et al. (1989) reported that the field experiment compared the efficiency of P uptake by maize for three P fertilizer sources using the P isotope dilution used were triple superphosphate (18.38% P), single superphosphate (7.02%P) and christmas Island rock phosphate (13.82% P). Most of the fertilizer P added was found in the stems and cobs of the maize plants followed by the leaves and flowers. The total P uptake by maize was significantly higher in the super phosphate treated plots as compared to the rock phosphate treated plots. About 6% of the P applied as superphosphate was used by the maize as compared to only 1% fromthe rock phosphate.

Poolland and Gilkes (1992) studied that the field experiment, in western Australia triticale was given 6 rates of triple superphosphate queensland rock phosphate and North Carolina rock phosphate. Grain yield was measured from 1984 to 1988 and soil sample were collected from 1985 to 1988. Soil extractable P was measured using different reagents. Bray 1, calcium acetate lactate, Truog and colwell. The relationship between soil test values, rate of P application and grain yield were determined either as absolute yield are percentage of the maximum yield. The relationship differed with fertilizer type, reagent and year. It was concluded that none of the soil test reagents studied was significantly better for predicting grain yields of triticale for the different P fertilizers applied providing only a rough guide for the P status of soils.

Jana and Das (1992) reported that the bioturbation by common carp fry in increasing the fertilizer value of phosphate rock in relation to microbiol phosphates activity was investigated in series of experiments using glass jars containing 9.3- cm layer of dry soil, rock phosphate at rate of 3.33 g/litre and common carp fry introduced per jar in the range of 1 to 12. The level of phosphate coupled with alkaline phosphate activity tended to rise in a logistic manner with an increase the number of common crop fry intruduced into the system. In any given treatment, alkaline phosphate activity of the water was directly correlated with phosphate level to a certain extent beyond which an inverse relationship between them was indicated.

Bolland (1993) studied that the relationship between plant yield and values of soils tests for phosphorus (P) in long term field experiment in south western Australia for soil previously fertilized with rock phosphate and superphopshate. The rock phosphate studied were; Queensland (Duchess) apatite rock phosphate; reactive apatite rock phosphate from North Carolina; and rock phosphate from christmas Island (as either C-grade ore or calciphos). The P fertilizer were applied once only at the start of each experiment, and in subsequent years, soil samples were collected in January March to measure soil test values.

Subehia and Minhas (1993) studied the different organic amendments on the P availability to wheat of Udaipur rock phosphate two years on a clay loam in Palampur, Himachal

Pradesh, India. P amendment were superphosphate at 39 kg P/ha and Udaipur rock phosphate at 39 and 78 kg P/ha. Rock Phosphate was mixed with either farm yard manure, chicken manure of biogass slurry. Superphosphate alone at 39 kg P/ha gave greater yields then rock phosphate at 78 kg P/ha but lower yields than rock phosphate at 39 kg P/ha. combined with poultry manure. Greatest relative yield efficiency, phosphate uptake and yield were obtained with rock phosphate at 78 kg P/ha and poultry manure.

Hanafi and Syers (1994) observed that the amount of phosphorus (P) dissolved in a closed· incubation system, in soils receiving christmas Island grade A phosphate rock (CIPR) , Gafsa Phosphate Rock (GPR) and triple super phosphate (TSP), as measured by extraction with 0.5 M $NaHCO_3$ (DELTAPG) or 0.5 M NaOH (DELTAP) and expressed, as DELTAPb/DELTAP* 100 (PDP) was compaed to P uptake (DELTAPs) by setaria in a glasshouse experiment. There was no direct relationship between DELTAPs and PDP for CIPR, GPR and TSP added at 50 and 150 mg P/kg soil to three Molaysin soils. During a 10 month period.

Szilar et al. (1998) reported that mobilization of Phosphate from soils under anaerobic conditions can be linked with reductive dissolution of iron from iron oxides. Among four soil samples from the reclaimed skjerna estuary in Denmark incubated anaerobically and amended with glucose, 28-39% of the dithionite citrate bicarbonate extractable iron and 10-25% of the oxalate extractable phosphorus (POX) were released to the soil solution after 31 days.

Jensen et al. (1998) studied the inoranic phopshate (P) associated with FE (III) (hydr) oxides can be mobilized by reductive in solution of the oxides. Bulk Ap samples from two loamy soils differing by nearly 50% in total P were amended with 6 or 60 mg glucose C/100 g soil at a water tension of 0.2 m. During 29 days of anoxic incubaton at room temperature, the soil solution pH, concentrations of Fe (II) and molybdate reactive P were measured. The concentrations of P were correlated to neither total soil P nor Fe (II) concentrations. Lack of Proportionality between Fe (II) and P in solution was attributed to microbial uptake, resorption of P and also, at high Fe (II) concentrations, to precipitation of Fe (II) compounds (eg vivianite). The highest P concentrations were observed in samples amended with the low C dose, where the concentratons increased six fold to 0.3 mg PO_4^- P/litre. This indicated that P leaching might increased from claying soils subjected to morderately reducing conditions.

Romer and Sehenk (1998) conducted the pot experiment, 24 high yielding spring barley cultivars were grown until maturity under P stress (50% of the maximum yield, or optimum P, or were grown until tillering under low of high P supply. At maturity, the range between cultivars with the highest and the lowest values were 30% for total dry matter yield (grain and straw), 28% for grain yield, 24% for P uptake efficiency (P in grain and straw), 26% for P concentration in grains and 24% for P utilization efficiency quotient.

Grain yield was correlated with P uptake per plant. There was only a weak relationship between P uptake.

Kobzarenko (1999) noted a data are presented on crop yield, plant P_2O_5 soil pH and acidity, sorption, saturation degree, and soil phosphate in six dernopodzolic soils supplied with phosphorus in an experiment in the Moscow region of Russia. The supply of P_2O_5 with limestone over 12 years gave values of 12.6- 28.0 mg/10 g soil (depending on the culture). Values of soil P_2O_5 were 4-11 times those in variants without limestone amendments. There was evidence of transformaton of phosphate forms by mobilization.

He et al. (1999) determined the laboratory analyses and green house experiments were conducted to evaluate effects of phosphate rock, COaL combustion byproduct, limestone, and cellulose application on the relationship between soil test P and crop growth in acidic soil. Application of phosphate rock, byproduct, limestone, and cellulose increased soil pH, exchangeable calcium and magnesium, and extractable P, and decreased free aluminium ion in the acid soil.

CHAPTER - III

MATERIALS AND METHODS

MATERIALS AND METHODS

Details of the materials used and techniques followed during the present investigation have been dealt within this chapter.

EXPERIMENTAL SITE :

The site for experiment was Agricultural farm of Sheila Dhar Institute of Soil Science which is located near Mumfordganj at Allahabad. The Agricultural farm bring irrigated by tubewell water supplied by the Jal Sansthan Allahabad. The field experiments were conducted during the year 2000 to 2002.

CLIMATE :

The climate of Allahabad in known for its cold winter and intolerable summers. The average rain fall about 92.1 cms and average temperature varied from 32.4 to 36.0 C with mean humidity of about 64 per cent.

SOIL CHARACTERISTICS :

Mostly soil of Allahabad district is old alluvial soil. The Sheila Dhar Institute farm has also alluvial soil, belonging to order inceptisol, suborder ochrepts, great group Eurochrepts, subgroup typic eurochrepts, family coarse silty, mixed thermic, series Natehez and the texture of soil is sandy clay loam. Soil is generally deficient in nitrogen organic carbon and zinc, moderate in phosphorus and sufficient in potassium.

FIELD EXPERIMENT:

The field experiment was conducted in the Sheila Dhar Institute farm in a factorial design laid out as Randomized Block Design having eleven treatment and three replication. The size of the microplot was 1 m x 1m.

COLLECTIN OF SOIL SAMPLES :

Bulk soil samples (0-15 cm) were collected with the help of an anger from various parts of the plot for the experimental purpose. The soil samples were also collected at 25, 50 and 75 days after sowing and at harvest.

PREPARATION OF SOIL SAMPLES FOR ANALYSIS :

The representative samples about 1.0 kg at each experimental plots were brought to laboratory and air dried in Shade wooden hammer was used for crushing and ponding the clods. After thorough mixing they were ground and then passed through 2 mm siene. The unsieved particles were again and again crushed thoroughly, mixed and finally passed through the same sieve. The soil sample thus prepared were kept in the same polythene bags and staked in the soil rack for analysis.

GRAIN AND STRAW YIELD :

At maturity each plot was harvested and threshed separately and gain yield was recorded in kg plot and expressed finally in q ha^{-1}

after adjusting 11 per cent moisture in gain. The straw yield was obtained by substracting grain yield from the total biological yield of each plot and expressed finally in q/ha^{-1}.

Methods employed for soil, compost and plant analysis:

A. Soil Analysis

1. Mechanical Analysis : Mechanical Analysis was done by Hydrometer method as given by Black (1955).

2. pH (1:25 soil water suspension)

pH value was measured by the pH meter, Elio, Model-L-110 Electronic Industrial Co. Pvt. Ltd. Hyderabad.

3. Organic Carbon : The organic carbon was determined by the modified Walkley and Black's method (Chopra and Kanwar) in which a known amount of the soil was disgested with disgested with potassium dichromate and sulphuric acid. The excess of chromic acid was back titrated with standard ferrous ammonium sulphate.

4. Cation Exchange Capacity : (cmol (+) Kg cation exchange was determined (Ammonium acetate extractable) by the method described by Jackson (1973).

5. Electrical Conductivity : Electrical conductivity S m^{-1} at 25°C of saturation extract was determined with th ehelp conductivity meter as outlined byJackson (1973).

6. Silt, clay and sand per cent in soil, by Chopra and Kanwar (1991). Silt - Percent of silt + clay in the soil. = $\frac{(W_2 - W_1)\ 1000 \times 100}{25 \times 20}$

Clay - Per cent clay = $\frac{(W_2 - W_1)\ 1000 \times 100}{25 \times 20}$

Sand - Percentage of sand. = $\frac{(W_2 - W_1)\ \ 100}{20}$

7. Determination of calcium and magnesium by EDTA (Athelin Diamin Tetracetic Acid) method.

8. Determination of Iron and Alluminium oxides by Chopra and Kanwar (1999).

9. Total and available lNitrogen : Total nitrogen was estimated by micro Kjedhl method as described by Kackson (1973) and available nitrogen was estimated by Alkaline Potassium Permangnant method as described by Tandon (1993).

AVAILABLE NITROGEN :

Procedure :

Place 20 g soil in a 800 ml dry kjeldahl flask. To this add 20 ml of water and whirl. Thenaded 1 ml of liquid paraffin and a few glase glade to the prevent frothing and Gumping respectively during distillation. Than add 100 ml each of 0.32% k Mn04 and 2.5% NaOH solution. Distill the contents in a kjeldahl assembly at a steady rate and collect liberated ammonia in a Erlenmayer flask k (250 ml) containing 20 ml of boric acid solution with (mixed indicator). With the absorption of ammonia, the pink colour of boric acid solution turn to green. Nearly 100 ml of distillate is to be collected in about 30 minutes. Titrate and contents with 0.02 $NH2SO_4$ to the original shade

(pink). Blank correction (without soil) is to be made for the final calculations.

CALCULATION :

Mineralizable N kg ha = R x 31.36

where R = Volume of 0.02 NH_2SO_4 required for titration.

10. TOTAL AND AVAILABLE PHOSPHORUS :

Total and available phosphorus content of soil was estimated as described by Dhyan Singh and R.N. Pandey (1998) respectively.

AVAILABLE PHOSPHORUS :

Olsen's $NaHCO_3$ Method : Sodium bicarbonates solution extracts some exchangeable or surface absorbed A1-P, Fe-P, Ca-P and other phosphate.

PROCEDURE :

* 2.5 g of soil sample was weighed and transferred in 100 ml conical flask.
* A pinch of Darco G-60 and 50 ml of Olsen's Reagent were added.
* Content was shaker for 30 minutes on a mechanical shaken.
* Filtered through whatman NO-1 filter paper.
* Transfered 5 ml of clear and colourles filtrate into a 25 ml volumetric flask.

Gradually 5 ml ammonium molybdate was added in solution containing 400 ml of 10 N HCl per litre.

* Slowly and carefully shaken to drive out the CO_2 evolved.

* When frothing completely ceases, distilled water was added washing down the sides, to bring the volume to about 22 ml.

* 1 ml of freshly diluted $SnCl_2$ solution, was added shake and a little and the volume was made to 25 ml.

* Blue colour intensity was read at 660 mm (red filter).

* A blank without soil under indentical manner was also run.

BRAY's Method :

* 5 g of soil sample was weighed in a 150 ml conical flask.

* 50 ml of Bray's P_1 extractant was added and shaken for 5 minutes.

* Filtered through Whatman No-1 filter paper quickly so as to collect the filtrate within 10 minuts.

* Transfered 5 ml aliquot into 925 ml volumetric flask.

* 5 ml of ammonium molybaddate was added to solution, shaken a little and diluted to about 22 ml.

* 1 ml of diluted $SnCl_2$(0.5 ml dilute to 66 ml) mixed was added and by Shakig a little and volume was made up.

* A blank without soil under identical conditions was also run.

* The intensity of the blue colour was developed using 660 nm wave length (red filter).

11. POTASSIUM :

Potassium of soil was estimated by (Normal ammonium acetate: M NH_4 OAC) the method described by Chopra and Kanwar (1999).

PHOSPHOCOMPOST ANALYSIS

Compost was determined by the method described by Chopra and Kanwar (1999).

PLANT ANALYSIS :

Tri acid digestion of plant sample :

Digestion was carried out using a 5:2:1 mixture of Conc. HNO_3, $HClO_4$ and Conc. H_2SO_4.

One gram of the ground plant material was placed in 100 ml conical flasks and 10 ml triacid mixture was added. The contents were heated on a hot plate at low heat for 30 minutes and the volume was reduces to about 5 ml or change the colour upto colourles or white.

After cooling the conical flask 20 ml distilled water was added contents filtered through whatman No. 2 filter paper into a 100 ml of volumetric flask and the volume in made up with distilled water. This solution was used for the determination of N,P, K and other aliments.

1. Nitrogen content in Plant : Kjeldahl digestion and estimation of total nitrogen in plant 0.5 g of over dry samples was weighed and transferred to kjeldahl flask. To this were added about 5 ml of concentrate H_2SO_4, 1 g $CuSO_4$ + K_2SO_4 (1:10) catalytic mixture and left over night. The samples were then digested. A reagent blank was run without sample. The bigest was then distilled with 40 per cent NaOH (20ml) in micro distillation set and evolved NH_3 was trapped in 5 ml of 4 per cent Goric acid indicator solution. The N content (as mg Ng^{-1} of sample) is determied by titrating with 0.05 NH_2SO_4 as described by Yoshida et al. (1976).

2. Phosphorus content in plant : 1 g ground plant material is placed in 100 ml conical flask. To this 10 ml of tri acid mixture is added and the content of the flask is mixed by swirling. The flask placed on low heat plate in digestion chamber. Then the flask is heated at higher temperature unit the production of red NO_2 fumes ceases. The contents are further evaporated until the volume is reduced to about 3 to 5 ml but not to bryness. The complition of digestion is confirmed when the liquid become colourless or white.

After cooling the flask added 20 ml of deionized or glass distilled water. Volume is made up with deionized water and the solution is filtered through whatman no-1 filter paper. Aliquots of this solution are used for determination of P, K, Ca, and other.

Phosphorus was determined in this extract by "vandomolybdate phosphate yellow method" as described by Jackson (1973).

3. Potassium content in plant : Potassium was estimated in acid extract after dilution with the help flame photometers.

12. NITROGEN UPTAKE :

The uptake of nitrogen at different intervals and at maturity was calculated by multiplying per cent content of nitrogen by dry matter yield and dividing by 100.

$$1n \text{ Kg ha}^{-1} \quad \frac{\text{content \% yield (kg)}}{100}$$

13

Inorganic phosphorus fractionation was also carried out as autlined by Jackson (1973) and Losen et. al. (1954).

14. PHOSPHORUS UPTAKE :

The uptake of Phosphorus at different in levels and at maturity as calculated by multiplying per cent content of Phosphorus by dry matter yield and dividing by 100.

$$1n \text{ (Kg ha}^{-1}) = \frac{\text{content (\%) yield (Kg)}}{100}$$

15. PHOSPHATE COMPOSTING :

Date of composting = 28.6.2000 after three month composition.

For composting pits of dimension 150 x 90 x 90 cm were each filled with 715 kg raw material comprising 85 kg straw, 65 kg, grasses, weeds and water hyacint and 565 kg farm wastes. To maintain sufficient moisture the material in each pit were moistured with 100 litres of water. The mixture in pit no 1, 2, 3 and 4 was

initially changed with 35.39 , 141.58, and 283.12 kg. of Mussorie rock phosphate have total P_2O_5 20.20% of which 0.013% was citric and soluble and 0.0039% water soluble.

T_1 = No P

T_2 = 1% P_2O_5 (as rock phosphate)

T_3 = 4% P_2O_5 (as rock phosphate)

T_4 = 8% P_2O_5 (as rock phosphate)

Experiment No. 1(A)

A field experiemnt was carried out to find the phosphate composting on soil plant relationship, effect on growth and yield parameters, phosphorus content in shoot at different growth intervals and at harvesting and in grains at Sheila Dhar experimental farm. Effect of these nutrients were also studied on response of the soil. The experiment was conducted during rabi and Kharif season of 2000-01 and 2001-02, Wheat variety WH-147, red gram variety "UP AS 120" and Paddy variety 'Sakit - 4' was growth as test crop both the years. Initial soil sample were collected from experimental farm and analysed for the physio chemical characteristics using standard methods, soil was found to have followoing composition as given in Table - A.

Experimental Details :

The field experiment was paid out in factorial experiment (R.B.D.) with eleven treatment combinations having three replication. The total number of plots was 33.

(1) Number of treatment = 11

(2) Replication = 3

(3) Size of plots = 1 x 1 sq.m.

(4) Date of sowing paddy = 8.7.2000

Wheat = 29.12.2000

Red gram = 18.06.2001

(5) Date of Harvesting = 10.12.2000 (Paddy)

= 3.4.2001 (Wheat)

= 18.3.2002 (Red gram)

Table - A - Physico-Chemical characteristics of soil used under field experiment.

S.No.	Soil properties	Year 2001
1.	pH (1:2.5)	7.8
2.	F.C.(dsm^{-1} at 25°C)	0.50
3.	C.E.C. (cmo 1(+) kg^{-1} soil	25.9
4.	Organic Carbon (%)	0.55
5.	Available nitrogen (kg/ha^{-1})	98.00
6.	Available phosphorus (kg/ha^{-1})	33.25
7.	Available Potash (kg/ha^{-1})	230
8.	Total Phosphorus (%)	0.063
9.	Totla Nitrogen (%)	0.048

Treatment combination :

T_1 = Control

T_2 = 10 Tans Phospho-compost (P.C.)

T_3 = N, P, K

T_4 = N, K, +5 Tons phospho- compost.

T_5 = N,K + 10 Tons Phospho-compost.

T_6 = 1/2 N, K + 5 Tons Phospho-compost.

T_7 = 1/2 N, K + 10 Tons Phospho-compost.

T_8 = 1/3 N,K + 5 Tons Phospho-compost.

T_9 = 1/3 N,K + 10 Tons Phospho-compost.

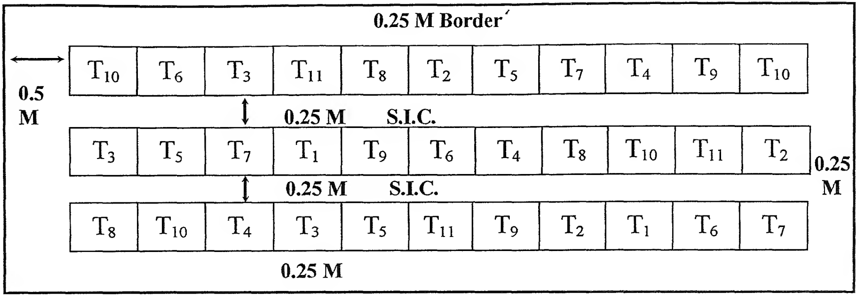
T_{10} = 2/3 N,K + 5 Tons Phospho-compost.

T_{11} = 2/3 N,K + 10 Tons Phospho-compost.

N = 46 % as urea

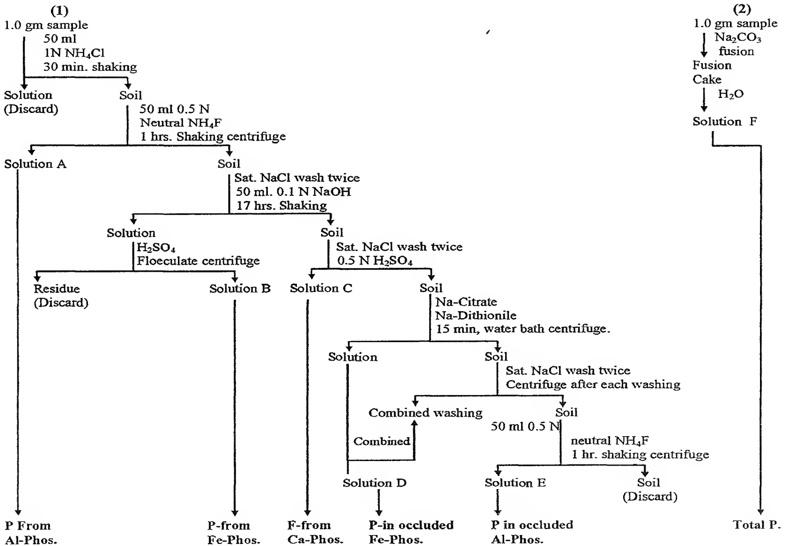
P = 16 % as single superphosphate

K = 60 % as in murate of potash.



Lay Out

M.I.C. = Main Irrigation Channel
S.I.C. = Sub Irrigation Channel


(1)
1.0 gm sample
50 ml
1N NH4Cl
30 min. shaking
Solution
(Discard)
Soil
50 ml 0.5 N
Neutral NH4F
1 hrs. Shaking centrifuge
Solution A
Soil
Sat. NaCl wash twice
50 ml. 0.1 N NaOH
17 hrs. Shaking
Solution
H2SO4
Floeculate centrifuge
Residue
(Discard)
Solution B
Soil
Sat. NaCl wash twice
0.5 N H2SO4
Solution C
Soil
Na-Citrate
Na-Dithionile
15 min, water bath centrifuge.
Solution
Soil
Sat. NaCl wash twice
Centrifuge after each washing
Combined washing
Combined
Soil
50 ml 0.5 N
neutral NH4F
1 hr. shaking centrifuge
Solution D
Solution E
Soil
(Discard)
P From
Al-Phos.
P-from
Fe-Phos.
F-from
Ca-Phos.
P-in occluded
Fe-Phos.
P in occluded
Al-Phos.
(2)
1.0 gm sample
Na2CO3
fusion
Fusion
Cake
H2O
Solution F
Total P.

CHAPTER - IV

RESULTS AND DISCUSSION

LAB.
EXPERIMENT

EXPERIMENT NO. 1

Profile study of U.P. alluvial soil in relation to available and inorganic P fractions.

Experimental :

Alluvial soil of Uttar Pradesh has been divided into 3 groups viz. (1) Eastern alluvium (2) Central alluvium (3) Western alluvium.

For detailed studies, soil profile samples were collected in the month of May 2001 in cultivated area in two replications 0 - 20, 20 - 40, 40 - 70, 70 - 100, 100 - 130 cm depth from following places:

1. Eastern alluvium:
   Azamgarh.
   (i) Shidhari
   (ii) Muhammedabad
   (iii) Thekma
2. Central alluvium
   Kanpur.
   (i) Pokhraya
   (ii) Kalyanpur
   (iii) Billaor
3. Western alluvium :
   Meerut.
   (i) Sambhauli
   (ii) Machhra
   (iii) Baraut

Soil samples were dried in shade and sieved through 80 mesh and stored for subsequent analysis. To make easy for discussion soil samples have given the symbols as below:

(1) Eastern alluvium soil

Azamgarh.

(i) Shidhari(A)

(ii) Muhammedabad (B)

(iii) Thekma (C)

(2) Central alluvium soil

Kanpur

(i) Pokhraya (D)

(ii) Kalyanpur (E)

(iii) Billaor (F)

3. Western alluvium :

Meerut.

(i) Sambhauli (G)

(ii) Machhra (H)

(iii) Baraut (I)

Table - 1

(I) Physico-chemical composition of U.P. Alluvial soil (Eastern Alluvial tract)

Soil Sample symbol	Depth (cm)	pH	Total N (%)	CaO (%)	Org. C (%)	Al_2O_3 (%)	Fe_2O_3 (%)	Clay (%)	Silt (%)	Total sand (%)
A	0-20	7.2	0.018	2.2	0.34	4.1	3.20	19.2	12.4	52.3
	20-40	7.2	0.017	2.4	0.28	4.25	3.30	19.8	12.8	51.2
	40-70	7.3	0.015	2.45	0.26	4.34	3.40	19.8	13.6	50.5
	70-100	7.4	0.015	2.5	0.22	4.50	3.45	20.0	13.9	48.9
	100-130	7.4	0.014	2.5	0.20	4.55	3.50	21.5	14.5	48.0
B	0-20	7.4	0.024	0.98	0.36	5.12	3.28	16.80	34.5	42.7
	20-40	7.4	0.023	1.15	0.35	5.16	3.35	17.50	36.4	40.1
	40-70	7.5	0.021	1.50	0.32	5.25	3.46	17.75	36.8	35.2
	70-100	7.6	0.020	1.75	0.30	5.30	3.46	18.24	38.2	30.5
	100-130	7.6	0.020	1.95	0.30	5.30	3.55	18.56	39.4	30.0
C	0-20	7.5	0.035	0.32	0.48	2.31	3.54	18.85	26.32	38.46
	20-40	7.75	0.032	0.35	0.45	2.36	3.58	19.20	26.87	36.35
	40-70	7.8	0.032	0.38	0.42	2.38	3.84	19.75	27.25	36.00
	70-100	7.8	0.031	0.38	0.40	2.46	3.89	19.75	27.76	30.90
	100-130	7.9	0.031	0.45	0.40	2.49	3.95	20.25	28.50	30.00

(II) Physico-chemical composition of U.P. Alluvial soil (Central Alluvial Tract)

D	0-20	7.4	0.03	0.21	0.72	4.52	3.82	19.26	31.5	48.3
	20-40	7.15	0.03	0.23	0.71	4.54	3.84	20.12	32.1	45.2
	40-70	7.85	0.02	0.25	0.70	4.58	3.88	20.75	33.2	42.6
	70-100	7.8	0.01	0.25	0.65	4.67	3.92	21.95	34.7	39.2
	100-130	7.8	0.01	0.26	0.60	4.85	3.98	24.76	35.0	38.6
E	0-20	7.3	0.04	0.90	0.68	4.20	3.65	15.87	30.6	56.2
	20-40	7.3	0.03	0.95	0.65	4.22	3.70	16.32	30.9	52.8
	40-70	7.4	0.03	1.00	0.60	4.26	3.78	16.95	32.4	51.3
	70-100	7.5	0.02	1.20	0.58	4.28	3.82	17.46	33.6	48.2
	100-130	7.5	0.02	1.25	0.52	4.34	3.92	18.64	34.5	45.8
F	0-20	7.9	0.14	0.75	0.85	5.21	3.54	21.42	28.9	49.7
	20-40	8.0	0.09	0.78	0.82	5.24	3.54	21.95	29.6	47.6
	40-70	8.0	0.08	0.82	0.76	5.35	3.58	22.52	31.5	43.2
	70-100	8.5	0.06	0.85	0.72	5.46	3.62	23.15	31.9	40.1
	100-130	8.5	0.06	0.89	0.70	5.60	3.70	24.26	32.8	38.9

(III) Physico-chemical composition of U.P. Alluvial soil (Western Alluvial Tract)

G	0-20	9.0	0.03	1.28	0.26	4.6	5.03	20.8	32.0	56.2
	20-40	9.2	0.02	1.29	0.27	4.8	5.05	21.7	33.7	54.1
	40-70	9.2	0.009	1.34	0.23	4.8	5.07	21.9	33.9	52.8
	70-100	9.4	0.008	1.35	0.22	4.9	5.09	22.2	34.4	51.7
	100-130	9.5	0.007	1.40	0.20	5.3	5.12	22.6	34.9	48.2
H	0-20	7.8	0.02	0.74	0.34	4.8	4.06	19.3	30.1	53.2
	20-40	7.8	0.01	0.78	0.33	4.9	4.09	19.8	30.8	52.4
	40-70	7.9	0.02	0.85	0.33	5.1	4.12	20.4	31.2	49.8
	70-100	8.0	0.006	0.88	0.30	5.2	4.19	20.9	31.9	49.9
	100-130	8.0	0.004	0.95	0.29	5.4	4.24	21.6	32.5	48.5
I	0-20	8.5	0.09	0.81	0.38	3.9	3.108	21.2	21.7	51.6
	20-40	8.7	0.07	0.84	0.37	4.2	3.16	21.4	22.6	51.4
	40-70	8.8	0.07	0.92	0.35	4.5	3.24	21.8	22.9	50.7
	70-100	8.9	0.05	0.99	0.33	4.5	3.29	22.7	23.7	50.1
	100-130	8.9	0.03	1.25	0.30	4.8	3.35	23.6	23.8	48.2

Table - 2

(I) Distribution of Phosphate (ppm) in the profiles of U.P. Alluvial soil (Eastern Alluvial Tract)

Soil Sample symbol	Depth (cm)	Saloid P	Fe-P	Al-P	Reductant Fe-P	Occl. Al-P	Ca - P	Organic -P	Inorganic -P	Available -P	Total P
A	0-20	10.4	65.70	106.00	91.32	10.24	325.2	75.00	740.00	38.00	815
	20-40	9.8	65.90	106.80	91.89	10.38	320.1	70.64	742.20	32.00	812
	40-70	7.6	67.61	107.25	93.25	10.97	320.0	68.21	744.16	28.72	810
	70-100	6.8	68.4	107.84	93.76	11.25	300.8	65.98	746.25	22.64	808
	100-130	5.9	69.5	108.00	96.25	12.64	295.6	65.21	746.78	21.35	805
B	0-20	7.8	39.4	80.75	94.75	7.24	294.7	69.20	635.31	28.31	776
	20-40	7.2	41.3	85.69	94.97	8.21	263.3	64.86	642.62	28.07	768
	40-70	6.9	44.2	88.21	96.21	9.63	265.5	55.75	687.21	25.17	756
	70-100	6.0	46.8	92.54	96.74	10.15	274.1	48.21	721.26	22.64	750
	100-130	5.1	53.2	94.21	99.25	10.87	242.6	44.64	735.21	18.75	748
C	0-20	8.6	41.2	88.32	88.71	9.21	261.2	88.27	580.21	21.36	698
	20-40	7.8	41.9	88.87	88.84	10.36	253.8	87.67	587.26	20.31	682
	40-70	6.9	45.2	92.64	90.45	10.72	246.7	84.97	591.38	19.42	672
	70-100	6.2	46.8	94.72	92.26	11.46	248.5	84.25	595.76	18.65	645
	100-130	5.7	49.7	98.00	93.00	12.25	227.3	81.86	600.00	16.72	618

(II) Distribution of phosphate (ppm) in the profiles of UP. Alluvial soil (Central Alluvial Tract)

D	0-20	12.6	70.10	115.24	97.85	10.37	300.18	70.62	720.15	40.76	892
	20-40	12.7	72.64	114.26	99.56	12.32	376.4	62.64	724.36	36.64	878
	40-70	9.3	74.28	113.78	110.32	14.85	362.2	54.25	726.21	32.37	857
	70-100	8.5	76.75	113.21	114.39	15.64	358.6	48.73	726.97	29.61	843
	100-130	8.2	79.42	112.35	115.37	16.85	351.2	44.54	728.65	29.65	840
E	0-20	11.7	58.32	110.27	87.26	6.87	322.6	66.24	698.25	38.39	776
	20-40	11.2	60.85	109.51	92.87	10.75	304.6	60.25	732.64	35.78	842
	40-70	10.4	62.68	107.62	96.35	12.21	376.9	54.75	746.89	32.41	835
	70-100	9.7	64.21	103.87	97.64	14.64	352.7	45.36	759.75	28.29	828
	100-130	8.9	65.63	100.39	98.35	17.32	348.3	40.32	765.21	26.65	824
F	0-20	12.7	68.21	107.28	94.76	7.83	265.7	82.74	686.21	42.42	750
	20-40	11.0	70.35	104.65	96.78	8.87	248.9	76.72	695.64	38.79	785
	40-70	9.5	72.46	100.76	97.69	10.65	238.2	68.98	735.24	36.64	864
	70-100	9.0	74.21	98.86	98.35	11.37	236.7	68.21	764.63	34.75	852
	100-130	8.4	76.67	98.21	100.00	12.54	232.8	65.29	794.85	32.82	845

(III) Distribution of phosphate (ppm) in the profiles of UP. Alluvial soil (Western Alluvial Tract)

G	0-20	9.20	41.00	60.20	190.0	38.0	301.60	60.30	686	42.3	775
	20-40	8.30	42.64	61.46	200.0	39.7	280.00	55.40	675	39.2	760
	40-70	7.10	44.25	63.67	210.0	50.3	275.00	52.68	658	36.7	751
	70-100	6.80	45.67	64.15	220.0	52.1	270.60	48.45	623	31.2	738
	100-130	6.00	55.20	64.76	225.0	58.7	265.00	42.00	620	30.5	707
H	0-20	10.9	70.24	92.64	150.0	19.8	354.00	64.00	764	48.1	835
	20-40	7.4	72.15	92.95	148.0	17.2	336.00	62.70	758	45.4	815
	40-70	6.3	74.00	94.20	138.0	12.5	315.60	58.00	732	42.7	770
	70-100	5.1	75.85	95.14	135.0	10.2	297.00	52.89	714	39.2	750
	100-130	4.2	75:10	95.78	132.0	10.0	282.60	50.32	693	36.7	717
I	0-20	8.2	32.00	51.76	220.0	48.3	297.00	52.21	640	40.8	740
	20-40	6.4	32.89	52.24	235.0	50.4	292.85	51.35	642	40.2	736
	40-70	5.3	34.37	52.87	238.0	60.3	276.00	47.10	635	39.1	714
	70-100	4.9	35.10	53.25	240.0	58.3	254.00	42.76	704	36.4	797
	100-130	4.2	35.87	54.54	245.0	55.4	223.85	38.36	700	35.2	748

Table - 3

P Relationship alongwith various Attributes

Sl.No.	Relationship between		r value
1	Total - P	Organic - C	0.77
2	Total - P	Total - N	0.68
3	Total - P	Saloid - P	0.58
4	Available - P	Total - P	0.50
5	"	Saloid - P	0.187
6	"	Al - P	0.41
7	Organic - P	Organic - C	0.87
8	"	Al - P	0.65
9	"	Fe - P	0.72
10	"	Silt + Clay	0.84
11	"	pH	-0.57
12	Ca - P	pH	0.55
13	"	Total - P	0.63
14	"	Organic - P	-0.31
15	"	Clay	-0.48
16	Fe - P	pH	0.72
17	"	Ca - P	-0.59
18	Al - P	Sand	-0.38
19	"	Silt	0.64
20	Saloid - P	Al - P	0.72
21	"	Ca - P	0.68

(r = correlatoin coefficient)

EXPERIMENT NO. 1 (A)

Surface soil sample of different tract of U.P. alluvial soil, mentioned in table - 1 have been selected for the present study. Physico chemical properties of soil were determined as desired by Jackson (1973) and Piper (1960).

Phosphate potential and lime potential of soil samples were determined by their respective equation as described by schofield and Taylor (1955).

Soil samples were treated with 0.01M $CaCl_2$ solution for 7 days with occasional shaking. After a week, following observations were recorded in the filtrate viz. pH of the solution, amount of phosphorus present in the solution.

Lime potential was calculated by Schofild's lime potential expression (pH - 1/2 P Ca) and phosphate potential was calculated as $pH_2\,OP_4$ + 1/2 P Ca where pH_2PO_4 was calculated as

$$pH_2PO_4 = -\log \frac{\dfrac{P}{2 \times 10^{-7}}}{1 + pH^{-7}}$$

Table No. 4

Physico-chemical characteristics of soil.

S.No.	Symbol for soil location	pH	Exch. Ca med./100g	CEC mol/100g	Organic carbon %	E.C.	Clay %	Silt %	Sand %
1	A	7.3	18.80	23.89	0.23	0.40	19.00	29.00	65.00
2	B	7.4	16.70	21.50	0.36	0.46	18.80	40.00	46.00
3	C	7.75	17.30	21.46	0.42	0.48	16.40	46.00	53.00
4	D	7.5	14.60	22.20	0.32	0.39	17.60	39.00	48.00
5	E	7.3	20.21	23.60	0.32	0.45	18.90	36.00	34.00
6	F	8.0	10.00	20.40	0.18	0.82	10.86	42.00	42.00
7	G	9.2	8.70	12.82	0.26	0.85	23.00	35.00	46.00
8	H	7.8	10.90	18.90	0.21	0.56	26.00	30.00	44.00
9	I	8.7	12.20	16.42	0.25	0.76	38.00	21.00	42.00

Table No. 5

Phosphate potential and lime potential of soil sample.

S.No.	Symbol for soil sample	pH	1/2 P Ca	pH_2PO_4	L.P.	P.P.	L.P.-P.P	5(L.P.) – 3(P.P.)	7 (L.P.) – 3 (P.P.)
1	A	7.3	0.67	5.40	6.63	6.07	0.56	14.94	28.20
2	B	7.5	0.75	5.25	6.75	6.00	0.75	15.75	29.25
3	C	7.8	0.72	5.42	7.08	6.14	0.94	16.98	31.14
4	D	7.5	0.76	5.31	6.74	6.07	0.67	15.49	28.97
5	E	7.4	0.74	5.22	6.66	5.96	0.70	15.42	28.74
6	F	8.0	0.55	5.70	7.45	6.25	1.20	18.50	33.40
7	G	9.2	0.63	5.84	8.57	6.47	2.10	22.84	40.58
8	H	7.9	0.70	5.36	7.20	6.06	1.14	17.82	32.22
9	I	8.8	0.60	5.65	8.20	6.25	1.95	22.25	38.65

L.P. = lime potential ; P.P. = Phosphorus potential.

Table No. 6

Correlation coefficient among various soil attributes :

1.	pH vs lime potential	0.92*
2.	Exch. Ca vs lime potential	-0.19
3.	C.E.C. vs lime potential	-0.78
4.	Org. C vs lime potential	0.24
5.	E.C. vs lime potential	0.83*
6.	Clay vs lime potential	0.40*
7.	Silt vs lime potential	-0.062
8.	Sand vs lime potential	-0.29
9.	pH vs phosphate potential	0.39**
10.	Exch. Ca phosphate potential	-0.38*
11.	C.E.C. vs phosphate potential	-0.44**
12.	Org. C vs. Phosphate potential	0.10
13.	E.C. vs Phosphate potential	0.35**
14.	Clay vs phosphate potential	0.12
15.	Silt vs phosphate potential	0.506*
16.	Sand vs Phosphate potential .	-0.52*

* Significant as 5% and 1% level.

** Significant as 5% level.

EXPERIMENT NO. 2

Four compost pits of dimension 150 x 90 x 90 cm were each filled with 715 kg raw material comprising 85 kg straw, 65 kg grasses and weeds and 565 kg farm waste. To maintain sufficient moisture with 100 litres of water. The mixture in pit no. 2, 3 and 4 was initialy charged with 35.39,141.58 and 283.18 kg respectively of ground Mussoorie rock phosphate having 20.15% total P_2O_5, 1.93% ammonium citrate soluble P_2O_5 and 17 pm water soluble P_2O_5.

T_1	:	No P
T_2	:	1% P_2O_5 (as rock phosphate)
T_3	:	4% P_2O_5 (as rock phosphate)
T_4	:	8% P_2O_5 (as rock phosphate)

Table - 7

Different forms of P in phospho-compost

Component	T_1	T_2	T_3	T_4
Total P (%)	0.52	0.96	3.34	4.20
Water soluble P (ppm)	5.64	14.25	9.75	7.50
Citrate Soluble P (%)	0.34	0.59	1.89	3.62
Organic P (%)	0.40	0.94	2.68	4.05
Inorganic P (%)	0.06	0.05	0.06	0.08

Table - 8

Fractionation of inorganic P in Phospho compost (ppm)

Form of P.	T_1	T_2	T_3	T_4
Al-P	6.0	11.8	10.2	7.9
Fe-P	87.2	57.4	63.7	75.2
Ca-P	216.4	174.3	192.6	221.0
Occl. Al-P	5.9	7.8	5.3	4.6
Occl. Fe-P	134.5	126.7	116.4	148.8
Inorganic P	600	500	600	800
Total P	5200	9600	33400	42000

Table - 9

Chemical characteristics of phospho-compost

Component	T_1	T_2	T_3	T_4
Total Ca(%)	1.78	2.24	4.29	5.21
Total Mg (%)	0.32	0.48	0.54	0.60
Total K (%)	0.89	0.76	0.86	0.92
Fe (ppm)	5072	12700	2864	3827
Mn (ppm)	178	498	693	829
Zn (ppm)	56	86	132	157
Cu (ppm)	9	22	28	38
pH	4.8	5.8	7.0	7.2
Organic Carbon (%)	13.76	16.07	10.75	8.65
Total nitrogen (%)	0.58	0.76	0.72	0.64

FIELD EXPERIMENT

EXPERIMENT NO. 1

Paddy

A field experiment was carried out to study the effect of phosphocompost and NPK on paddy crop at the Sheila Dhar Institute, Research plots. As the topic of the thesis concerns with the "Phosphated composting on soil-plant relationship," Phosphocompost application was directly done to the fields which was supposed to get converted in humus through different microbial processes.

The following treatments were selected for the studies:

		Rate of application
1.	Control	—
2.	Phosphocompost	10 tones ha^{-1}
3.	Nitrogen, Phosphorus, Potash	100, 80, & 60 kg ha^{-1}
4.	N,K, and Phosphocompost	100 kg, 60 kg, 5 tons ha^{-1}
5.	N, K and Phosphocompost	100 kg, 60 kg, 10 tones ha^{-1}
6.	1/2 N, K and Phosphocompost	50 kg, 30 kg, 5 tons h^{-1}
7.	1/2 N,K, and Phosphocompost	50 kg, 30 kg, 10 tons ha^{-1}
8.	1/3 N, K and Phosphocompost	33.33 kg, 20 kg, 5 tons ha^{-1}
9.	1/3 N,K and Phosphocompost	33.33 kg,20 kg,10 tons ha^{-1}
10.	2/3 N,K and Phosphcomost	66.66 kg, 40 kg, 5 tons ha^{-1}
11.	2/3 N,K and Phosphocompost	66.66 kg, 40 kg, 5 tons ha^{-1}

The efficiency of these materials has been evaluated on the basis of crop growth, yield and yield attributes. Plant and grain contents for P have also been discussed on the basis of their analysis. The test crop baddy (Oryza sativa) variety. Saket-4 was taken for this experiment. The results of this experiment have been properly recorded and discussed in table.

Table No. 10

Effect of Phosphocompost on plant height (cms) in paddy crop.

Treatment	Height (cm)		
	30 DAS	60 DAS	90 DAS
T_1	25.0	35.0	70.0
T_2	28.0	45.0	80.0
T_3	36.0	75.0	98.0
T_4	36.0	70.0	96.0
T_5	38.0	78.0	105.0
T_6	30.0	65.0	86.0
T_7	32.0	70.0	88.0
T_8	28.0	58.0	82.0
T_9	30.0	67.0	85.0
T_{10}	33.0	70.0	91.0
T_{11}	34.0	73.0	94.0
SE (m) ±	2.116	1.029	1.906
CD at 5 %	4.414	2.148	3.977

Table No. (11)

Effect of Phosphocompost on numbers of tillers at different stages of paddy crop growth

Treatment	Number of tillers		
	25 DAS	45 DAS	65 DAS
T_1	34.8	41.6	42.3
T_2	44.9	52.8	55.7
T_3	48.5	60.4	61.2
T_4	48.2	59.9	61.0
T_5	52.7	64.8	65.6
T_6	46.0	56.2	56.8
T_7	46.2	57.6	58.1
T_8	45.2	54.8	56.2
T_9	45.9	55.4	58.4
T_{10}	46.8	58.0	58.9
T_{11}	47.4	58.9	59.7
SE (m) ±	2.19	1.734	1.685
CD at 5%	4.568	3.1617	3.514

Table No. (12)

Effect of Phosphocompost on Grain, straw kg ha^{-1} and plant population m^2 at harvest time in paddy crop.

Treatment	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	Plant Population m^2
T_1	20.3	35.0	250
T_2	32.5	45.0	326
T_3	34.5	55.0	340
T_4	34.4	52.5	340
T_5	35.8	60.0	352
T_6	34.1	50.0	330
T_7	34.4	51.5	332
T_8	33.5	47.5	328
T_9	34.0	49.5	330
T_{10}	34.4	52.0	335
T_{11}	35.1	54.5	338
SE (m) ±	0.299	0.327	2.63
CD at 5 %	0.624	0.682	5.49

Effect of Phosphocompost on Grain, straw kg/ha and plant population m^2 at harvest time in paddy crop.

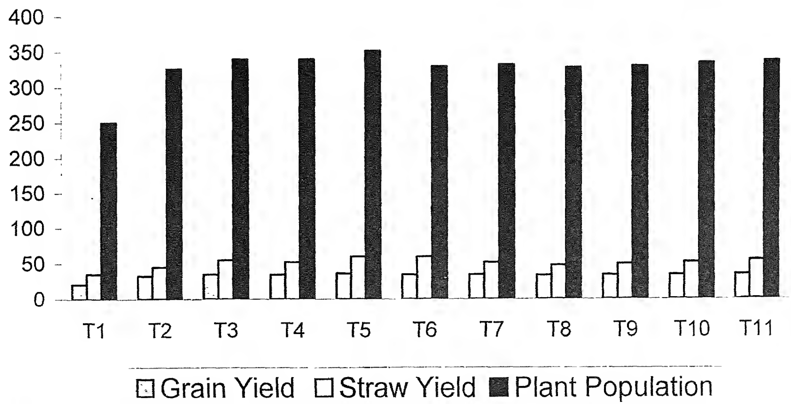


Table No. (13)

Effect of Phosphocompost on Bray P (kg ha^{-1}) at various growth stages Bray P Kg ha^{-1} in paddy crop.

Treatment	Maximum tillering stage	Penicle initiation stage	Harvesting stage
T_1	42.0	34.0	18.0
T_2	53.0	43.0	29.0
T_3	49.0	39.0	27.0
T_4	50.0	41.0	32.0
T_5	65.0	56.0	36.0
T_6	49.0	38.0	24.0
T_7	56.0	45.0	28.0
T_8	45.0	36.0	22.0
T_9	50.0	42.0	27.0
T_{10}	54.0	48.0	31.0
T_{11}	62.0	50.0	34.0
SE (m) ±	0.123	0.136	0.013
CD at 5 %	0.256	0.285	0.027

Table No. (14)

Effect of Phosphocomost on P-uptake (mg/plant) at various stages in paddy crop.

Treatment	Maximum tillering stage	Penicle initiation stage	harvesting stage
T_1	6.5	19.0	29.3
T_2	7.2	23.2	36.1
T_3	9.8	23.8	38.2
T_4	9.4	24.9	40.6
T_5	11.7	31.5	47.3
T_6	8.5	23.4	36.4
T_7	9.3	25.8	38.8
T_8	8.5	31.3	30.7
T_9	8.7	22.9	34.2
T_{10}	9.8	27.5	37.8
T_{11}	10.6	28.9	42.1
SE (m) ±	0.232	0.60	0.226
CD at 5 %	0.483	1.26	0.470

Effect of Phosphocompost on P-uptake (kg/ha) at various stages in paddy crop

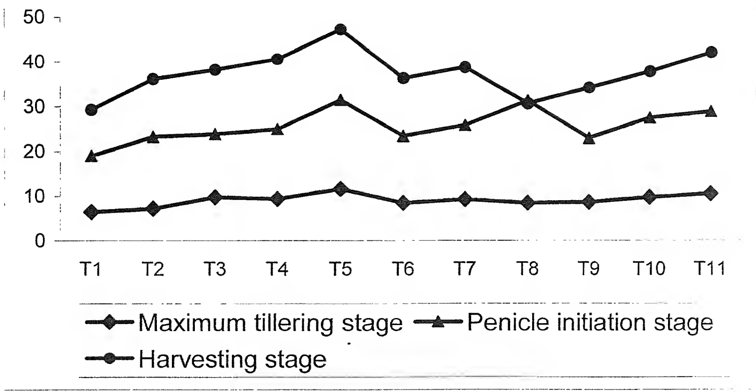


Table No. (15)

Effect of phosphocompost on P-content (%) and its uptake (kg ha^{-1}) in paddy grain.

Treatment	P. Content (%)	P. uptake (kg ha^{-1})
T_1	0.256	7.66
T_2	0.277	9.00
T_3	0.298	10.28
T_4	0.310	10.27
T_5	0.350	12.17
T_6	0.285	9.71
T_7	0.315	10.83
T_8	0.275	9.21
T_9	0.300	10.37
T_{10}	0.320	11.0
T_{11}	0.338	11.69
SE (m)±	0.021	0.025
CD at 5 %	0.045	0.0507

Table No. 16

ıount of total and Available nutrient in soil after harvesting paddy crop as influenced by phosphocompost d NPK.

No.	Treatment pH	Nitrogen (%)		Phosphorus (ppm)		Potash (ppm)	
		Total	Available	Total	Available	Total(%)	Available
1	T_1	0.049	0.0038	445	4.98	1.73	128
2	T_2	0.070	0.0070	530	9.132	1.76	156
3.	T_3	0.078	0.0061	540	7.702	1.79	166
4	T_4	0.080	0.0068	674	10.89	1.78	178
5	T_5	0.088	0.0076	830	11.870	1.84	181
6	T_6	0.073	0.0065	786	10.210	1.77	166
7	T_7	0.074	0.0067	795	10.640	1.78	169
8	T_8	0.070	0.0069	746	9.150	1.76	159
9.	T_9	0.073	0.00064	775	9.850	1.75	164
.0.	T_{10}	0.079	0.0068	798	10.870	1.79	176
1	T_{11}	0.083	0.0071	819	11.326	1.82	178

EXPERIMENT NO. 2

A field experiment was carried out during 2000-01 to the study the effect of phosphorus containing substances through the application of phosphocompost, a basal application of nitrogen was also done for sake of comparison an usual NPK at the rate of 120 : 80 : 60 kg ha^{-1} was applied as the basal dose, Wheat was grown as the test crop selecting variety WH= 147.

S.No	Treatment	Rate of application ha^{-1}
1.	Control	
2.	Phosphocompost	10 tones
3.	N, P, K	120, 80 & 60 kg
4.	N,K, and Phosphocompost	120 kg, 60 kg, and 5 tons
5.	N, K and Phosphocompost	120 kg, 60 kg and 10 tons
6.	1/2 N, K and Phosphocompost	60 kg, 30 kg and 5 tons
7.	1/2 N,K, and Phosphocompost	60 kg, 30 kg, and 10 tons
8.	1/3 N, K and Phosphocompost	40 kg, 20 kg and 5 tons
9.	1/3 N,K and Phosphocompost	40 kg, 20 kg, and 10 tons
10.	2/3 N,K and Phosphcomost	80 kg, 40 kg, and 5 tons
11.	2/3 N,K and Phosphocompost	80 kg, 40 kg, and 10 tons

Table No. (17)

Effect of phosphocompost on plant height (cms) wheat crop.

Treatment	(Height cms)		
	30 DAS	60 DAS	90 DAS
T_1	22.3	28.6	75.7
T_2	26.7	32.3	90.4
T_3	33.4	42.8	128.9
T_4	33.6	42.3	127.7
T_5	35.8	45.3	135.8
T_6	28.6	36.8	120.9
T_7	29.7	38.5	123.8
T_8	26.3	32.9	110.7
T_9	28.2	34.2	115.7
T_{10}	30.9	38.6	127.5
T_{11}	32.4	40.3	128.7
SE (m) ±	0.743	1.724	0.432
CD at 5 %	1.552	3.598	0.901

Table No. 18

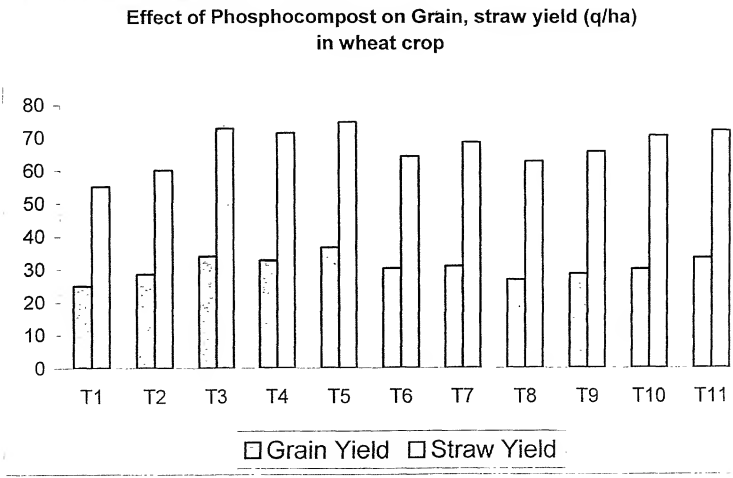
Effect of phosphocompost on tillers at succesive stages of crop growth of wheat crop.

Treatment	Number of tillers		
	30 DAS	60 DAS	90 DAS
T_1	9	20	28
T_2	15	32	50
T_3	25	34	58
T_4	20	38	59
T_5	28	47	65
T_6	18	33	50
T_7	21	37	53
T_8	15	30	45
T_9	18	35	49
T_{10}	23	38	54
T_{11}	25	44	56
SE (m) ±	2.27	2.20	2.59
CD at 5%	4.74	4.59	5.40

Table No. (19)

Effect of Phosphocompost on grain and straw yield (q ha^{-1}) in wheat.

Treatment	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})
T_1	24.9	55.0
T_2	28.5	60.00
T_3	33.9	72.60
T_4	32.7	71.30
T_5	36.6	74.70
T_6	30.4	64.30
T_7	31.1	68.70
T_8	26.9	62.70
T_9	28.8	65.70
T_{10}	30.2	70.50
T_{11}	33.5	72.10
SE (m) ±	0.772	0.694
CD at 5 %	1.507	1.448



Effect of Phosphocompost on Grain, straw yield (q/ha)
in wheat crop
80
70
60
50
40
30
20
10
0
T1
T2
T3
T4
T5
T6
T7
T8
T9
T10
T11
Grain Yield
Straw Yield

Table No. 20

Effect of phosphocompost on P content (%) at different successive plant growth in wheat crop.

Treatment	P content (%) in Tillering stage	P content (%) in jointing stage	P content (%) in Milking stage
T_1	0.17	0.087	0.027
T_2	0.25	0.120	0.030
T_3	0.28	0.19	0.046
T_4	0.29	0.21	0.049
T_5	0.38	0.26	0.068
T_6	0.23	0.18	0.032
T_7	0.26	0.20	0.036
T_8	0.22	0.14	0.029
T_9	0.26	0.17	0.031
T_{10}	0.29	0.20	0.044
T_{11}	0.32	0.25	0.056
SE	0.021	0.019	0.017
CD at 5%	0.043	0.039	0.035

Table No. (21)

Effect of Phosphocompost on P-content (%) in wheat crop.

Treatment	P content (%) in Grain	P content (%) in Straw
T_1	0.20	0.043
T_2	0.21	0.052
T_3	0.23	0.078
T_4	0.25	0.050
T_5	0.26	0.081
T_6	0.23	0.052
T_7	0.24	0.053
T_8	0.21	0.045
T_9	0.23	0.048
T_{10}	0.24	0.061
T_{11}	0.26	0.066
SE (m)±	0.025	0.0025
CD at 5 %	0.053	0.0053

Table No. (22)

Effect of phosphocompost on N content (%) in wheat crop.

Treatment	N Content (%) in grain	N content (%) in Straw
T_1	1.02	0.19
T_2	1.04	0.19
T_3	1.16	0.29
T_4	1.12	0.21
T_5	1.09	0.25
T_6	1.07	0.22
T_7	1.14	0.22
T_8	1.21	0.21
T_9	1.16	0.20
T_{10}	1.20	0.22
T_{11}	1.15	0.23
SE (m) ±	0.028	0.014
CD at 5 %	0.059	0.029

Table No. (23)

Effect of Phosphocompost on P-uptake (kg ha^{-1}) in wheat crop.

Treatment	P uptake (kg ha^{-1}) in Grain	P uptake (kg ha^{-1}) in Straw
T_1	5.11	2.40
T_2	6.20	3.20
T_3	8.27	5.80
T_4	7.85	3.60
T_5	8.30	6.10
T_6	6.47	3.40
T_7	7.15	3.70
T_8	6.30	2.70
T_9	6.87	3.10
T_{10}	7.43	4.30
T_{11}	8.28	4.80
SE (m) ±	1.334	0.274
CD at 5 %	2.783	0.572

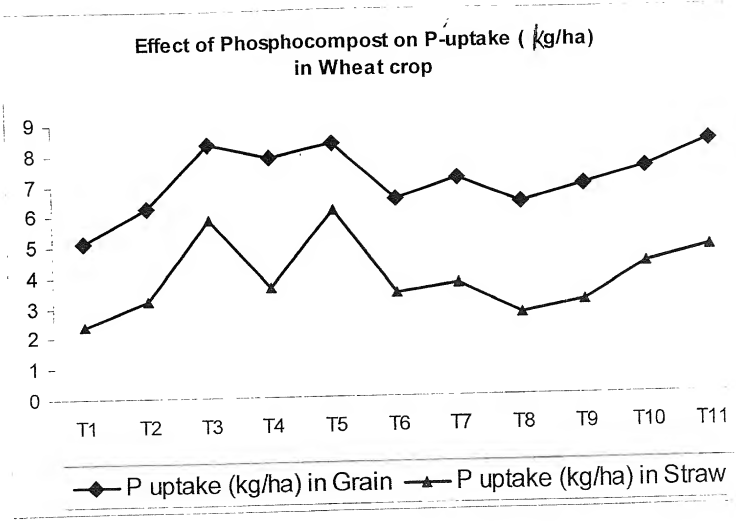

Effect of Phosphocompost on P-uptake (kg/ha)
in Wheat crop
9
8
7
6
5
4
3
2
1
0
T1
T2
T3
T4
T5
T6
T7
T8
T9
T10
T11
P uptake (kg/ha) in Grain
P uptake (kg/ha) in Straw

Table No. (24)

Effect of Phosphocompost on N uptake (kg ha^{-1}) in wheat crop.

Treatment	N Uptake (ka ha^{-1}) in grain	N uptake (kg ha^{-1}) in straw
T_1	25.5	10.5
T_2	30.0	11.2
T_3	39.5	17.7
T_4	37.0	15.1
T_5	40.0	18.5
T_6	33.8	14.3
T_7	35.6	15.1
T_8	32.8	12.9
T_9	33.6	13.5
T_{10}	36.5	15.7
T_{11}	38.7	16.9
SE (m) ±	0.424	0.450
CD at 5 %	0.885	0.939

Effect of Phosphocompost on N uptake (kg./ha) in what crop.

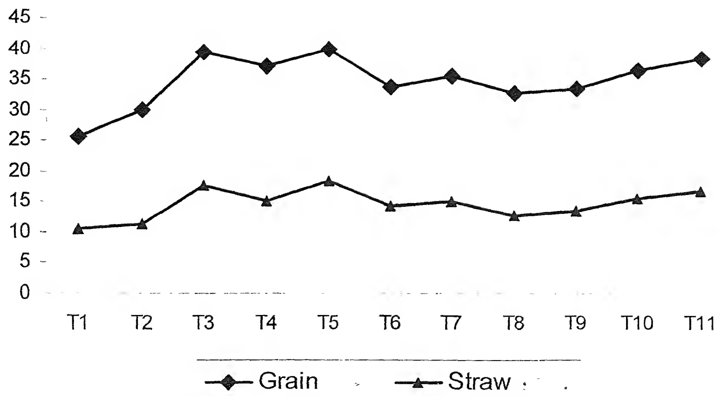


Table No. 25

Amount of total and Available nutrient in soil after harvesting wheat crop as influenced by phosphocompost and NPK.

S.No.	Treatment	pH	Nitrogen (%)		Phosphorus (ppm)		Potash (ppm)	
			Total	Available	Total	Available	Total(%)	Available
1	T_1	7.80	0.048	0.0036	447	4.96	1.70	127
2	T_2	7.50	0.068	0.0067	525	9.140	1.74	155
3.	T_3	7.62	0.076	0.0060	669	7.70	1.77	164
4	T_4	7.59	0.079	0.0065	825	10.84	1.75	179
5	T_5	7.48	0.085	0.0074	783	11.82	1.82	180
6	T_6	7.52	0.070	0.0063	791	10.21	1.74	167
7	T_7	7.50	0.073	0.0066	798	10.64	1.76	168
8	T_8	7.61	0.068	0.0059	742	9.15	1.74	157
9.	T_9	7.58	0.071	0.0062	770	9.80	1.72	163
10.	T_{10}	7.53	0.077	0.0067	795	10.76	1.77	174
11	T_{11}	7.49	0.082	0.0069	814	11.25	1.79	176

EXPERIMENT NO. 3

A study was conducted in the field of Sheila Dhar Institute of Soil Science to find out the phosphocompost with different doses of nitrogen and potash in red gram (Cajanus cajan (L) Mill sp.) crop. The experiment was carried out in randomized block design with a plot size 1 x 1 m. All treatments were replicated thrice. Physio-chemical properties of experimental soil are mentioned in table .

Phosphate was applied in the form of phosphocompost and single superphosphate, nitrogen and potassium was supplied in the form of urea and muriate of potash @ 15 and 30 kg ha^{-1} respectively. Red Gram (Arhar) UPAS 120 was grown as the test crop.

S.No	Treatment	Rate of application kg ha^{-1}
1.	Control	
2.	Phosphocompost	10 tones
3.	N, P, K	15 kg, 30 kg, and 40 kg
4.	N,K, and Phosphocompost	15 kg, 30 kg and 5 tons
5.	N, K and Phosphocompost	15 kg, 30 kg and 10 tons
6.	1/2 N, K and Phosphocompost	7.5 kg, 15 kg and 5 tons
7.	1/2 N,K, and Phosphocompost	7.5 kg, 15 kg, and 10 tons
8.	1/3 N, K and Phosphocompost	5 kg, 10 kg and 5 tons
9.	1/3 N,K and Phosphocompost	5 kg, 10 kg, and 10 tons
10.	2/3 N,K and Phosphcomost	10 kg, 20 kg, and 5 tons
11.	2/3 N,K and Phosphocompost	10 kg, 20 kg, and 10 tons

Table No. 26

Effect of phosphocompost on plant height (cms) in red gram crop.

Treatment	Height (cms)		
	30 DAS	60 DAS	90 DAS
T_1	30	90	165
T_2	34	95	178
T_3	40	105	225
T_4	40	104	222
T_5	45	115	238
T_6	34	100	214
T_7	36	103	219
T_8	32	96	198
T_9	34	99	208
T_{10}	37	105	225
T_{11}	39	108	229
SE (m) ±	1.214	1.642	1.257
CD at 5%	2.532	3.425	2.623

Table No. (27)

Effect of phosphocompost on branching and nodulation of red gram (Cajanus cajan) crop

Treatment	Primary branching	Second branching	Number of nodules/plant	Nodule dry wt./plant (mg)
T_1	4.00	2.00	4.00	30.00
T_2	5.00	3.00	7.00	50.00
T_3	9.00	6.00	6.00	75.00
T_4	9.00	5.00	8.00	80.00
T_5	10.00	6.00	11.00	95.00
T_6	6.00	4.00	8.00	65.00
T_7	7.00	5.00	9.00	70.00
T_8	5.00	3.00	5.00	70.00
T_9	6.00	4.00	7.00	75.00
T_{10}	7.00	5.00	8.00	80.00
T_{11}	8.00	6.00	10.00	85.00
SE (m) ±	0.71	0.75	1.089	4.41
CD at 5%	1.48	1.565	2.270	9.19

Table No. (28)

Effect of phosphocompost on grain, straw yield in red gram crop.

Treatment	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})
T_1	10.00	50.00
T_2	13.50	57.00
T_3	17.50	64.00
T_4	17.00	63.00
T_5	18.00	65.00
T_6	16.50	60.00
T_7	17.00	63.00
T_8	15.00	57.5
T_9	16.50	59.5
T_{10}	17.00	62.5
T_{11}	17.50	64.0
SE (m) ±	0.875	1.026
CD at 5%	1.825	2.141

Effect of Phosphocompost on Grain, straw yield (q/ha) in red gram crop

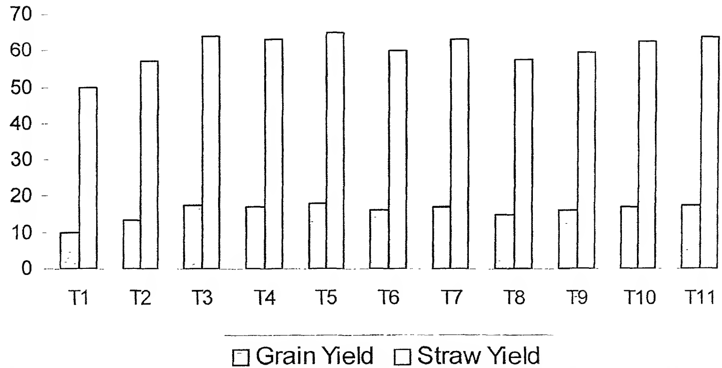


Table No. 29

Available nutrient in soil after harvesting red gram (Cajanus cajan) crop influenced by oranic matter and NPK:

Treatment	pH	Nitrogen (%)		Phosphorus (ppm)		Potash (ppm)	
		Total	Available	Total	Available	Total(%)	Available
T_1	7.5	0.086	0.0065	440	4.20	1.60	116
T_2	7.2	0.140	0.0104	516	8.85	1.64	143
T_3	7.6	0.146	0.0110	664	7.53	1.67	151
T_4	7.4	0.154	0.0116	800	10.64	1.65	169
T_5	7.1	0.165	0.0128	767	11.21	1.76	175
T_6	7.4	0.143	0.0114	785	10.12	1.52	160
T_7	7.3	0.148	0.0116	790	10.46	1.58	167
T_8	7.5	0.140	0.0106	740	9.32	1.32	142
T_9	7.4	0.143	0.0109	766	9.62	1.41	153
T_{10}	7.2	0.150	0.0116	787	9.98	1.54	162
T_{11}	7.1	0.156	0.0123	795	10.28	1.59	168

DISCUSSION

EXPERIMENT NO. 1

Physico-chemical characteristics of soils are given in Table 1 (I, II, III) which are classified according to region or tract. Different fractions of inorganic phosphate in profiles of U.P. Alluvial soils are mentioned in table 2 (I, II, III). Correlation coefficient (r) among various attributes are presented in table -3.

Total - P

Data shown in table 2 (I,II,III) reveal that total phosphorus content of alluvial soils varied from 618-892 ppm with mean value of 735.091 ppm. Similar range of total P (322.67 - 841 ppm) for tropical soil of kankan (Tamil Nadu) was also reported by Deshmukh et al. (1982). It was observed that in general, total phosphorus content showed a declining order with increasing order of depth except 'E' and 'F' type of centre alluvial soil. Increased content of total P in sub surface soil of E & F types might be due to higher content of total phosphorus in the parent alluvial.

In eastern alluvial soils of highest total P is obtained in A type soil (815 ppm) and the lowest in C type (618 ppm). Total P content in eastern alluvium soils have been arranged as below in their decreasing order:-

A > B > C

Data of central alluviam soils reveal that maximum amount of total phosphorus present in D type soil (892 ppm) and the minimum in the F type soil (750 ppm).

Distribution pattern of total P in central alluvial soils is mentioned below in their decreasing order:

D > F > E

Western aluvium soils have been found total P content as below in descending order :

H > I > G

Significant correlation of total phosphorus was also observed with organic carbon (r = 0.77), with total nitrogen (r = 0.68) and with saloid P (r = 0.58).

Available P

Maximum accumulation of available P (Olsen's) was found in the surface layer of all the profiles and decreased with depth table 2 (I, II, III). Similar trend was also noticed by Pareek and Mathur (1969) and Patel and Mehta (1962). This may be due to distribution pattern of organic carbon, pH, Fe_2O_3, Al_2O_3 and clay content in soils and also the requirement of crop and the rooting depth of the crop.

Available P was found to vary from 16.72 ppm to 48.14 ppm with average value of 30.36 ppm in alluvial soils of U.P. similar range (11.80 - 38.7 ppm) was also reported by Chauhan et al. (1974) for some Rajasthan soils. Variation in available P content may be due to cultivation, fixation of P, and nature of soil.

Eastern alluvium soils were found to possess the highest value (38.00 ppm) in A type soil and lowest in C type soil (16.72 ppm). Following trend was observed in different eastern alluvium soils:

A > B > C

Content of available P in western alluvium soils of G, H and I were found 39.3 , 45.4, and 40.2 ppm respectively.

I type soil of central alluvium have maximum amount of available P (40.76 ppm) while E type soil contain minimum (26.65). Following trend was observed among central alluvial soils:

F > D > E

Available phosphorus exhibited positive relationship with the total P (r = 0.50), with the saloid P (r = 0.187) and with the Al - P (r = 0.41). Similar relationship of available P was also found by Bhan and Shankar (1973).

Organic P

Phosphate which is derived secondarily by the addition of organic matter to the soil through the growth of plants and the deposition of plant residue is known as organic phosphate.

D type soil of central alluvium was observed to contain higher amount of organic P (70.62 ppm) and least amount (38.36 ppm) in I type soil of western alluvium. This fraction contributed 10.27% in case of I soil of western alluvium and 15.36% in case of D soil of central alluvium. The decrease in organic P content in soil along with the depth. These results are in agreement with those of Metha and Patel (1963). Bhandari and Saxena (1968) reported that amount of organic P ranges from 10 ppm in deep layer to 159.0 ppm in the surface layer.

Distribution of organic P in U.P. alluvial soils evaluated as follows:

Eastern alluvium - C > A > B

Central alluvium - F > D > E

Western alluvium - H > I > G

Organic P was found to have positive correlation with the org. C (r = 0.87) with Al- P (0.65) with the Fe-P (r=0.72) and with the silt and clay (r= 0.84) and negative correlation with pH (r = -0.57). Similar correlation was also recorded by Bhatia and Shanker (1982).

Inorganic P

An examination of the data shows in table 2 (I, II, III) that inorganic P content of alluvium soil are higher in comparison to other alluvium tracts. Higher content of inorganic P was observed in F type soil of central alluvium (794.85 ppm) and lowest in soil of C in western alluvium soil (580.21 ppm).

Average contribution of inorganic P to total P was found to posses (91.46%) . These observations are in the conformity of those reported Bapat et al.(1965).

A type soil has highest amount of this fraction among eastern alluvial soil (740.00 ppm) and lowest in the C type soil (580.00 ppm). Sequence of inorganic P content in eastern alluvium soil is as follows:

A > B > C

Contribution of this form in central alluvium and western alluvium soils is mentioned as follows:

D > E > A and H > G > I

Calcium P (Ca-P)

The western Ca-P in H type soil of central alluvium was observed to be maximum (354.00 ppm) and minimum in I soil of western alluvium (232.86 ppm). The results were more or less in agreement with these reported by Srivastava and Pathak (1968).

Data indicated that this fraction dominated in all the soils. This may be attributed to the calcareous nature of soil. The dominance of Ca-P in calcareous soil was also reported by Ramdeo and Rahal (1972).

The content of Ca-P in eastern alluvium soils showed a wide variation ranging from 222.7 - 325.2 ppm. Results are found in the following in decreasing order:

A > B > C

Highest Ca-P was found in A soil (325.2 ppm) of eastern alluvium as well as H of western alluvium soil (354.00 ppm) and lowest (223.86 ppm). Order of position help among soils are as below:

Western alluvium	=	H > I > G
Central alluvium	=	E > D > F
Eastern alluvium	=	A > B >C

The correlation analysis indicated that Ca - P was significantly positive correlation with pH (r =0.55) with the total P (r= 0.36) and negative correlation with organic P (r = 0.31) and with the clay (r = -0.48) .

Iron Phosphate (Fe-P)

The Fe-P was found to range 32.00 - 70.10 ppm. Higher amount of Fe-P was observed in D soil of central alluvium (70.10 ppm) while least in I soil of western alluvium (32.00 ppm) . Trend in mentioned below in increasing orders:

Western alluvium	=	H > G > I
Eastern alluvium	=	A > C > B
Central alluvium	=	D > F > E

The correlation of iron phosphate with pH was found to be positive (r = 0.72) while with Ca-P was negative (r = -0.59). It means decrease in Ca-P , increased the amount of iron phosphate. These findings were also recorded by Chang ( ) and Chopra and Kanwar (1999) who observed that Ca-P might be converted to iron phosphate as a result of chemical weathering.

Aluminium Phosphate (Al-P)

A wide variation was noted in the Al-P fraction and its value ranged from 31.00 to 60.00 ppm with average value of 58.61 ppm. Contribution of Al - P to total P was observed from 6.37% - 8.60% .

Similar percentage of Al - P to total - P was also recorded in alluvial soil of Tamilnadu by Kathandaraman and Krishnamoorthy (1979).

Fraction of Al - P varied in eastern, central and western alluvium soils from 80.75, 98.21 and 51.76 ppm to 108, 115.24 and 95.78 ppm respectively.

Variation trend was recorded from soil to soil as mentioned below in descending order.

Eastern alluvium	=	A > C > B
Central alluvium	=	D > E > F
Western alluvium	=	H > G > I

Aluminium phosphate was found to be negatively correlated with sand (r = – 0.38) and positively correlated with silt (r = 0.64).

Saloid - P

It is the smallest fraction of inorganic - P which constituted 1.47 - 4.25% of total P in different alluvium tract of U.P. Maximum amount of this fraction was found in F type soil of central alluvium (12.7 ppm) while the least in the B type soil of eastern alluvium (7.80 ppm).

Bhan and Shanker (1973) also observed similar results for U.P. alluvial soils i.e. 3.99 - 4.16% .

In perusal of value in table 2 saloid - P was found to occur as follows in decreasing order:

Eastern alluvium	=	A > C > B
Central alluvium	=	F > D > E
Western alluvium	=	H > G > I

Correlation analysis is revealed that saloid - P exhibited significant positive correlation with Al-P (r = 0.72) and with the Ca-P (r=0.68).

Reductant phosphate :

The inorganic phosphates that did not dissolve in alkaline and acid solutions are know to be soluble in a reductant mentioned the reductant and its strength. This type of inoranic-P fraction in called reductant phosphate.

Contribution of reducant phosphate (Reductant Fe-P + Occluded Al-P) to total P was found to vary from 8% to 32% reductant Fe P fraction appears to have higher value in comparison to Occl. Al-P.

The maximum amount of Red. Fe-P as wel as occl. Al-P was observed in I type soil of western alluvium (220 ppm) and 48 ppm respectively and the minimum in A and E type soils of eastern and central alluvium (91.32 and 6.87 ppm) respectively.

Definite trend of distribution of this fraction was not however observed. Similar view was also given by Desmukh et al. (1982).

Distribution of red. Fe-P in different soils may be arranged in the following order :

Eastern alluvium	=	B > A > C
Central alluvium	=	D > F > E
Western alluvium	=	I > G > H

Following order can be observed regarding the occl. Al-P content in different soil Profiles:

Eastern alluvium	=	A > C > B
Central alluvium	=	D > E > F
Western alluvium	=	I > G > H

EXPERIMENT NO. 1(A)

It is revealed from table - 4 that soils ranged from 7.3 - 9.2 pH. Organic carbon has been found sufficient in quantity in most of the soils and medium in cation exchange capacity.

The phosphate potential and lime potential was calculated as suggested by Schofiled and Taylor (1955) which is given in table 5. Mean value of the lime potential and phosphate potential were found to be 7.25 and 6.14 respectively. On perusal of data (table 5) it is found that out of the 9 soils. 3 are above the mean values of lime potential and 4 are above the phosphate potential and remainings are below te mean values.

The relationship between pH and $pH_2 PO_4$ has been presented in Fig. (1). The solubility isotherm of lindsay and Moreno (1960) for DCP, OCP and HA are represented as straight line of different slopes. The soils can be classified into two groups. The soil ABCD and H indicated as A are predominant in DCP and remaining are mixture of DCP and OCP which fell near the DCP and OCP isotherm. The points of soil F, I and G fell on the OCP isotherm having lower solubility due to the steepness of the slope and pH higher than other soils . Similar findings were also reported by Abbas (1980) in some alluvial soil of U.P.

Chopra and Kanwar (1999) emphasized the possibility of formation of mixture of Ca - P of varying solubility oin soil depending on pH values.

The equation used for plotting the lime potential (pH -1/2 P Ca) against the phosphate Potential (pH_2PO_4 + 1/2 P Ca) in Fig. (II) table -5 for three types of ca- phosphate are as follows:

for DCP (Ca $HPO_4.2H_2O$) - Russell (1961)

(pH - 1/2 P Ca) - pH_2PO_4 1/2 P Ca) = 0.66

for OCP (Ca_4 $H(PO_4)_3.3H_2O$) - Moreno et al. (1960).

5 (pH - 1/2 P Ca) - 3 (pH_2PO_4 1/2 P Ca) = 11.70

for HA (Ca_{10} $(PO_4)_6$. $(OH)_2$ - Russell (1961)

7 (pH - 1/2 P Ca) - 3 (pH_2 PO_4 + 1/2 P Ca) = 14.70

The relationship between lime potential and phosphate potential and their solubility products. with different calcium phosphate forms have been presented in table - 5 and illustrated in Fig. (II) by which the solubility isotherm of DCP, OCP and HA have been obtained . It is clear from Fig.(II) that the experimental soils fall in two distinct groups viz. DCP dominant and OCP dominant. From Fig. (II) it is observed that soil A,B,C,D. and H are dominant in DCP indicated as I and other two groups indicated as II and III both having sleeper slopes showed formation of less soluble octa calcium phosphate besides dicalcium phosphate. It is exhibited that DCP present in soils is more soluble as compared to HA but less soluble than OCP.

The correlation coefficient among various soil attributes were also worked out and mentioned in table - 6.

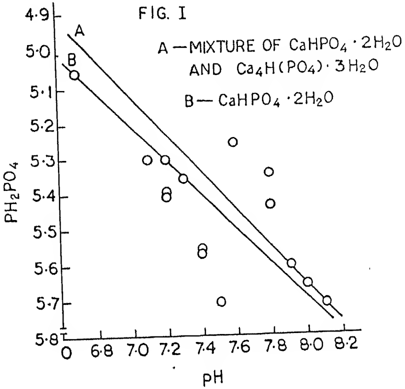


FIG. I
A — MIXTURE OF CaHPO4 · 2H2O AND Ca4H(PO4)· 3H2O
B — CaHPO4 · 2H2O
A
B
PH2PO4
4·9
5·0
5·1
5·2
5·3
5·4
5·5
5·6
5·7
5·8
0
6·8
7·0
7·2
7·4
7·6
7·8
8·0
8·2
pH

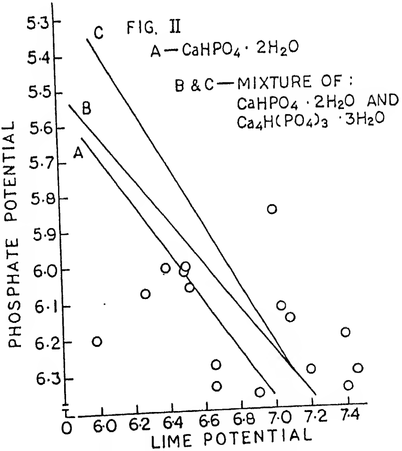


FIG. II
A — CaHPO4 · 2H2O
B & C — MIXTURE OF : CaHPO4 · 2H2O AND Ca4H(PO4)3 · 3H2O
C
B
A
PHOSPHATE POTENTIAL
5·3
5·4
5·5
5·6
5·7
5·8
5·9
6·0
6·1
6·2
6·3
0
6·0
6·2
6·4
6·6
6·8
7·0
7·2
7·4
LIME POTENTIAL

EXPERIMENT NO. 2

It is seen from table 3 that total P content in the composts did not vary in the same ratio in which rock phosphate was added possibly becaue of the heterogeneous nature of the composting wastes, which also contained variable amounts of P. It was noted with interest that the different amounts of rock phosphate was applied in treatments T_1, T_3 and T_4 and the percentage total P content of the phosphocompost got increased. Mathur et al. (1980) observed similar phenomenon during composting with varying P levels.

Table 3 further reveals that while the function of water soluble P in compost did not exceed 0.2 per cent of the total P due to incorporation of rock phosphate, a high amount of added P was recovered in citrate soluble form. The compost charged with rock phosphate in different amounts of citrate soluble P i.e. T_2–0.59, T_3-1.89 & T_4–3.62 per cent in the material prepared in phosphocompost.

Although the citrate soluble P like the water soluble form, was the highest (3.62%) in the compost prepared with higher amount of rock phosphate (T_4), the fraction extracted by neutral ammonium citrate of the total P was less than that in treatment 3; Release of P from rock phosphate in presence of compost may be due to the solubilizing action of organic acids produced during microbiological decomposition of organic materials. Chaudhary and Mishra (1980)

reported that effectiveness of different complexants for increasing dissolution of rock phosphate was in the order citric acid > oxalic acid > farmyard manure.

During composting a large proportion of rock phosphate P was converted into organic form (table 3) . It appears that in the absence of competition by plants and Ca, Fe, and Al ions, was in the soil system, microbial immobilization of P is likely to be more pronounced. Ghoshal and Johnson (1975) found that microorganism readily consumed and immobilized the applied fertilizer P which was remineralized slowly.

Fractionation of inorganic P in compost (Table 4) showed that a major portion of rock phosphate P was changed into Ca - P and Fe - P apparently due to the presence of Ca and Fe in Mussoorie rock phosphate. The inorganic P in the compost was bound in the decreasing order of abundance as Ca-P, occluded Fe-P, Fe-P, Al-P, occluded Al-P. Addition of rock phosphate did not change appreciably the concentration of different fractions, of inorganic P in compost and the increase in unextracted P from T_2 to T_4 was obviously due to the unreacted rock phosphate from which phosphate could not be extracted by the reagents employed for fractionation.

From the chemical composition of the four composts given in table 5, it is noted that addition of low dose of P (1% P_2O_5) as rock phosphate in the composting material improved the total nitrogen content by about 32%. Similar results with phosphate charged

compost were reported by Shukla and Pathak (1960) and Mandal and Jha (1970). Koravkin (1952) showed that composting of dung with phosphorite meal accelerated decomposition of organic matter by increased total microbial population but the decrease in denitrifying bacterial reduced the loss of nitrogen and hence there was a rise in nitrogen content in P treated compost. Mathur et al. (1980) observed greater microbial count in compost charged with lower dose of P_2O_5 (ranging from 1 to 4%) but the population decreased tremendously and microbial activity was inhibited when the level of P_2O_5 in compost was increased to 8 per cent as rock phosphate. This provides an explanation why with higher dose of phosphate (T_4) , nitrogen percentage in compost did not go up (Table 5). Thus, the readily oxidisable organic carbon content of the compost charged with higher amount of rock phosphate (T_4) was lower than that of the product obtained with low dose of phosphate (T_2).

The pH values of rock phosphate charged compost got increased because of the presence of the calcium carbonate in rock phosphate. Rock phosphate also increased the calcium and magnesium content of compost. Enriching the compoost with rock phosphate enhanced the concentration of micronutrients particularly of Fe and Mn (Table 5).

It is thus seen that charging the compost with rock phosphate not only enhanced the availability of P from the insoluble source by its dissolution but also improved the quality of the final product.

EXPERIMENT NO. 1

Crop height —

The height of paddy crop as affected by different doses of phosphocompost and NPK at various intervals have been presented in table-10. It clearly indicates that the height of plants at 20, 40 and 60 DAS increased significantly over the control. No particular trend among all the treatments could be observed in respect of height of the plants at variosu intervals. These results are in agreement with the finding of Chaudhury et al. (1971) and Abbas (1980) .

In increasing crop height at different stages of growth viz. 30, 60 and 90 DAS of paddy as influenced by different treatments over the control plots has been worked out and presented in following table:

Table - A

Increase in crop height (cms) over the control :

S.No.	Treatment	(%) increase over control		
		30 DAS	60 DAS	90 DAS
1	T_2	12.00	28.57	14.28
2	T_3	32.00	114.28	40.00
3	T_4	32.00	100.00	37.14
4	T_5	52.00	122.85	50.00
5	T_6	20.00	85.71	22.85
6	T_7	28.00	100.00	22.71
7	T_8	12.00	65.71	17.14
8	T_9	20.00	91.42	21.42
9	T_{10}	32.00	100.00	30.00
10	T_{11}	36.00	108.57	34.28

Number of Tillers:

The data pertaining to number of tillers in paddy crop at 25 DAS prestnted in table -11 indicate that the maximum number of tillers per plant was observed in NK at 100 : 60 kg level alongwith 10 tons Phosphocompost. It was interesting to note that the treatment containing NPK did not show any remarkable difference with the

number of tillers. However there was an increase in tiller formation when phosphocomost was applied with different treatments. A perusal of data on number of tillers per running meter of paddy crop after 25, 45 and 65 days of transplanting represented in table-11. The maximum growth of tillers per running meter was recorded with N (100 kg), K (60 kg) and 10 tons phosphocompost treatment.

The number of tillers at different stages viz. 25, 45 and 65 DAS of paddy as influnced by different treatments over the control plots have been worked out and presented in following table.

Table -B

% increase of numbers of tillers over the control.

S.No.	Treatment	(%) increase over control		
		25 DAS	35 DAS	45 DAS
1	T_2	29.02	26.92	31.67
2	T_3	39.36	45.19	44.68
3	T_4	38.50	43.99	44.20
4	T_5	51.43	55.76	55.08
5	T_6	32.18	35.09	34.27
6	T_7	32.75	38.46	37.35
7	T_8	29.88	31.73	32.86
8	T_9	31.89	33.17	38.06
9	T_{10}	34.48	39.42	39.24
10	T_{11}	36.20	41.58	41.13

Grain yield and Straw yield —

Data on grain and straw yield of rice are presented in table-12. It reveals that the application of phosphate maintained the higher crop yield. The highest yield of paddy (34.8 q ha^{-1}) was recorded when N (100 kg), K (60 kg) and phosphocompost (10 toms) to the soil was applied . It was interesting to note that NPK and NK at different doses, alongwith 5 and 10 tons phosphocompost were found to be equally effective. All the treatments were significant at 5% level over the control. Application at 5 tons and 10 tons of phosphocompost significantly increased the growth. A significant result was obtained by N,K application alongwith phosphocompost followed by N,P,K with regards the fertility ratio. The different doses of P was influenced by yield and plant populaton summarised in table-C. The maximum plant populaton at harvesting stage was observed with treatment no. 5 containing (N (100 kg), K (60 kg) and Phosphocompost (10 tons). These observations were supported by the finding of Rajgopalan (1987) , Gopal Rao (1991) Kumar and Singh (1997) .

The increase in crop yield of grain, straw and plant populaton of wheat as influenced by different treatments, over the control plots has been worked out and presented in following table.

Table NO.-C

S.No.	Treatment	(%) increase over control		
		Grain yield	Straw yield	Plant population/m^2
1	T_2	60.09	28.57	30.40
2	T_3	69.95	57.14	36.00
3	T_4	69.45	50.00	36.00
4	T_5	76.35	71.42	40.80
5	T_6	67.98	42.85	32.00
6	T_7	69.45	47.14	32.8
7	T_8	65.02	35.71	31.2
8	T_9	67.48	41.42	32.0
9	T_{10}	69.45	48.57	34.0
10	T_{11}	72.90	55.71	35.2

Bray extractable P at different growth stages—

The labile P (Bray-1) status of the soil decreased as the crop growth advanced from the maximum tillering stage up to the harvest (Table-13). At the maximum tillering stage significant variation in labile P was noticed due to P doses. When P was given in the form of phosphocompost (10 tons), the labile P was considerable high as compared to single super phosphoate. The high amount of

Bray extractable P in soil which received P as phosphocompost, nitrogen and potash indicates the beneficial effect of using phosphocompost on the crop response.

The available phosphorus in soil increased upto tillering stage, beyond which it gradually reduced. The decrease in the soil available P after harvesting stage may be due to formation of insoluble compounds in the soil and the removal of phosphorus by the crop at the early stages of its growth. Kalabande (1983) pointed out that about 85% of the phosphate applied was found to be fixed by the soil in 60 days.

The highest value of P availability was recorded at 60 days in the soil irrespective of different doses. The increase in availability at earlier stages could be due to higher mineralisation than fixation (Dravid and Apte, 1975). Initially, the availability of phosphorus was significantly high with phosphocompost treatment (T_5), which rapidly got decreased at the tillering and harvesting stage. The treatment T_5 remained at par with phosphocompost in contributing available - P to plant growth.

The increase in soil Bray extractable P at different stages of growth viz. tillering, panicle initiation and maturity, as influenced by different treatments over the control plots has been worked out and presented in following table .

Table -D

Increase in Bray extractable P over the control

S.No.	Treatment	(%) increase over control		
		Maximum Tillering stage	Panicle initiation stage	harvesting stage.
1	T_2	26.19	26.47	61.11
2	T_3	16.66	14.70	50.00
3	T_4	19.04	26.47	77.77
4	T_5	54.76	64.70	100.00
5	T_6	16.66	11.76	33.33
6	T_7	33.33	32.35	55.55
7	T_8	7.14	5.88	22.22
8	T_9	19.04	23.52	50.00
9	T_{10}	28.57	41.70	72.22
10	T_{11}	47.61	47.05	88.88

Significant response of phosphocompost was observed at all growth stages over the treatments containing P alone while different doses of P influenced the Bray extractable P of soil. Similar results regarding phosphocompost response was also noted by Sushama et al. (1993).

P-uptake at different growth stages—

P-uptake at different growth states viz. tillering, Panicle formation and harvesting was found to follow the similar trend of Bray-P at different stages. P-uptake in mg/plant was correlated signficantly with the crop yield. Maximum uptake (11.7, 31.5 and 47.3 mg/plant) was recorded in the treatment No. 5 while minimum uptake (6.5, 19.0 and 29.3 mg/plant) was found in control set table-14. P-uptake with the appliction of phosphocompost and NPK at different doses (kg/ha^{-1}) at maximum tillering stage was found to be 6.5, 7.2, 9.8 9.4, 11.4, 8.5, 9.3, 8.5 8.7 , 9.8 and 10.6 mg/plant respectively and at panicle initiation stage was found to be 19.0 , 23.2, 23.8, 24.9, 31.5, 23.4, 28.8, 31.3, 22.9, 27.5 and 28.9 mg/plant respectively and at harvesting stage it was found to be 29.3 , 36.1, 38.2, 40.6, 47.3, 36.4, 38.8, 30.7, 34.2, 37.8, and 42.1 mg/plant respectively.

P-content in grains —

A perusal of the data in table-15, P-content of grains was markedly influenced by the application of at different doses. P-content in grain was found in the order of 0.256, 0.277, 0.298, 0.310, 0.350, 0.285, 0.315, 0.275, 0.300, 0.320, and 0.338 per cent due to the application of phosphocompost and NPK at different doses respectively.

A significant response of phosphocompost was observed in P-content over the treatment containing P-alone. while doses of P-influence the P-content of paddy significantly. Similar results

regarding single super phosphate over the phosphocompost was also noted by Niranjan and Singh (1998).

P-Uptake by grains—

P-uptake by grains was found to follow the similar trend of P-content in grains. P-uptake was correlated significantly with the yield of grain. Maximum uptake (12.17 kg ha^{-1}) was recorded in the treatment No. 5 while minimum uptake (7.66 kg ha^{-1}) was found in control set. P-uptake with the application of phosphocompost and NPK at different doses (kgha^{-1}) by grain was found to be 7.66, 9.00 , 10.25, 10.27, 12.17, 9.71, 10.83, 9.21, 10.37, 11.00 and 11.69 kg ha^{-1} respectively.

Soil analysis after harvesting —

Analysis of soil after harvesting the paddy crop has been recorded in the table-16. The pH of soil was reduced slightly when it was treataed with Phosphocompost and NPK application was compared to the control. Treatments where fertilizers were applied, soils could not show any change in the pH value. The reason may be due to production of certain organic acids when organic matter decomposition take place.

Nitrogen , phosphorus and potassium also were determined and recorded in table-16. The total and available nutrients got increased in phosphocompost treated soils as compared with fertilizer treated soils. Organic matter (Phosphocompost) is the primary source of humus or humus like substance. It improves the

structure of soil, its drainage and aeration also increases its water holding capacity, buffer and exchange capacities influences, the solubility of soil minerals, and serves as a source of energy for the development of micro organism (Bremner 1956).

EXPERIMENT NO. 2

It is apparent from the data mentioned in table 17-25 that graded level of P application increased grain , straw and dry matter yield of wheat. Phosphate was supplied as single superphosphate (60 kg ha^{-1}), 5 tons and 10 tons phosphocompost were added and their effect on crop growth (height) and yield have been observed. The maximum grain yield (36 q ha^{-1}) starw (74. 7 q ha^{-1}) of wheat recorded with treatment No. 5 containing 120 kg N ha^{-1}, 60 kg K ha^{-1} and 10 tons phosphocompost.

Height (cms) wheat crop :

The data presented in table (17) and Fig.( ) indicated that the height of wheat after 30, 60 and 90 days of sowing the minimum crop height i.e. (22.5, 28.6, 75.7 cms) respectively was observed in the control plots.

Plant height increased significantly with application of nitrogen and potash along with phosphocompost. The maximum heights at 60 and 90 DAS stages was observed at treatment no. 5 followed by T_4, T_3, T_{11} and other treatments. The minimum plant height was observed in the control set at 60 and 90 days after sowing stages. The basal dose of nitrogen and potash along with phosphate supply by phosphocompost have appreciable influence on the plant height and crop growth.

Phosphocompost is better source of available phosphorus (Bangar et al. 1989). Nitrogen is an important factor for vegatative growth and when applied along with phosphocompost gave favourable crop growth response . The increase in plant growth with phosphorus and potash might also be better due to increased utilization of nutrients by the crops. These results are in agreement with the finding of Mishra et al. (1982) Singh (1985) and Bangar (1989).

The increasing crop height at different stages of growth viz. 30, 60 and 90 DAS of wheat as influenced by different treatments over the control plots has been worked out and presented in following table.

Table - A

Increase in crop height (cms) over the control.

S.No.	Treatment	(%) increase over control		
		30 DAS	60 DAS	90 DAS
1	T_2	19.73	12.93	19.41
2	T_3	49.78	49.65	70.27
3	T_4	50.67	47.90	68.69
4	T_5	60.54	58.39	79.39
5	T_6	28.25	28.67	59.70
6	T_7	33.18	34.61	63.54
7	T_8	17.93	15.03	43.31
8	T_9	26.46	19.58	52.84
9	T_{10}	38.56	34.96	68.42
10	T_{11}	45.29	40.90	70.01

Number of Tillers—

The data presented in table (18) and Fig. ( ) indicated that the tillers of wheat at 30, 60 and 90 DAS, the minimum tillers i.e. (9, 20, and 28) were observed in control plots respectively.

Plant tillers increased significantly with application nitrogen and potash along with phosphocompost. The maximum tillers at 60 and 90 DAS was observed with treatment No. 5 followed by T_{11}, T_{10}, T_3 and other treatments . The minimum number of tillers was observed in the control plots at 60 and 90 DAS. The basal dose of nitrogen and Potash along with phosphate supply by phosphocompost have appreciable influence on the production of tillers.

Phosphocomposts are better source of available phosphorus and other nutrients which are important factors for root formation and vegetative crop growth. The increasing plant growth with phosphorus and potash might also be better due to utilization of nutrients. These results are in agreement with the findings of Bangar (1989) .

The number of tillers at different stages viz. 30, 60 and 90 DAS of wheat as influenced by different treatments over the control plots has been worked out and presented in following table.

Table-B

% increase of numbers of tillers over the control.

S.No.	Treatment	(%) increaseof number of tillers		
		30 DAS	60 DAS	90 DAS
1	T_2	66.66	60.00	78.57
2	T_3	177.77	70.00	107.14
3	T_4	122.22	90.00	110.71
4	T_5	211.11	135.00	132.14
5	T_6	100.00	65.00	60.00
6	T_7	133.33	85.00	89.28
7	T_8	66.66	50.00	60.71
8	T_9	100.00	75.00	75.00
9	T_{10}	155.55	90.00	92.85
10	T_{11}	122.22	120.00	100.00

Grain yield and Straw yield —

The effect of phosphocompost and fertilizers on grain yield and straw yield were recorded in table (19). From the perusal of results from table (19) it can be concluded. that the N, K along with phosphocompost gave maximum response on crop growth. It was interesting to note that NPK and N & K at different doses along with 5

and 10 tons phosphocompost were found to be equally effective. All the treatments were significant at 5% level over the control. Application of 5 tons and 10 tons phosphocompost significantly increased the growth. A significant result was obtained by N,K application along with phosphocompost followed by N, P, K with regards the fertility ratio.

The increase in crop yield of grain and straw of wheat as influenced by different treatments over the control plots has been worked out and presented in following table .

Table No. C

S.No.	Treatment	(%) increase over control	
		Grain yield	Straw yield
1	T_2	14.45	9.09
2	T_3	36.14	32.00
3	T_4	31.32	29.63
4	T_5	46.98	35.18
5	T_6	22.08	16.90
6	T_7	24.89	24.90
7	T_8	8.03	14.00
8	T_9	15.66	19.45
9	T_{10}	21.28	28.18
10	T_{11}	34.53	30.09

As for as organic matter is concerned the phosphocompost was found to give higher yield followed by N,P,K and phosphocompost treatment. All the treatments were significant over the control at 5% level. Grain yield and straw yield were increased significantly with the application of phosphocompost and fertilizer sources. Table -19, indicates an increased grain yield over the control set by the application of phopshocompost. From results it may be inferred that the oranic matter is the raw material for humic acid, and it works as a store house of nutrients. The organic matter first gets converted to humic acid through undergoing different phases of microbial action. It slowly supplies nutrients to the crop, while fertilizers are the readily available source for nutrients, as essential micronutrients may also support the crop growth and yield effectively.

Phosphocompost proved better as comparable to the single super phosphate and gave better P-effeciency than it table-19. Perhaps the effect of phosphocompost was partly owing to the release of phosphate from the P assimilated in microbial biomass and partly owing to the release of P fixed on rock phosphate during composting. The effect of phosphocompost could not be completely owing to organic P because it accounted for only about 2% of the total P and even this small amount was not completely mineralized during crop season.

Application of single superphosphate has shown beneficial effect in comparison to phosphocompost on grain yield and straw

yield. It may be due to higher water soluble P uptake. Similar possibilities has been reported by Singh (1985) and Bangar et al. (1989).

P. Content at different growth stages—

P content in wheat at different successive stages of growth as influenced by various treatments, have been presented in table ( ). Data reveal that maximum amount of P was present at the tillering stage followed by jointing stage.

It may be due to high requirement of nutrient by plants at primary stage and the release of phosphoate from some phosphatic sources. Water soluble phosphatic fertilizers showed release of maximum P upto 30 days (Verma 1972).

Maximum accumulation (0.38%) of P was found with the phosphocompost, 10 tons kg ha^{-1} application at tillering stage and the least at milking stage (0.026%) in treatment no. 8.

The increased P content at different stages of growth viz. tillering, jointing and milking stage of wheat as increased by different treatments over the control plots has been worked out and presented in following table :

Table -D

P content (%) in different growth stages over the control.

S.No.	Treatment	P - content % increase over the control		
		Tillering stage	Jointing stage	Milking stage
1	T_2	47.07	37.93	11.11
2	T_3	64.70	118.30	70.37
3	T_4	75.8	141.37	81.48
4	T_5	123.52	198.80	151.85
5	T_6	35.29	106.80	18.51
6	T_7	52.94	129.88	33.33
7	T_8	29.41	60.91	7.40
8	T_9	52.94	95.40	14.18
9	T_{10}	75.8	129.88	62.96
10	T_{11}	88.2	187.35	107.40

A significant response of phosphocompost was observed at all growth stages over the treatments containing P alone. While dose of P influenced the P content of wheat significantly. Similar results regarding phosphocompost response was also noted by Singh (1982).

P- content in grain and Straw of wheat—

Wheat grain —

The perusal of the data in table-21, P content of grain was markedly influenced by the application of P at different doses. P content in grain was found in the order of 0.21 , 0.23 , 0.25, 0.26, 0.20, 0.22, 0.23, 0.23, 0.22 and 0.24% due to the application of phosphocompost and N, P, K at different doses respectively.

A significant response of phosphocompost was observed on P content over the treatments containing P alone. While doses of P influenced the P content of wheat significantly. Similar results regarding single superphosphate over phosphocompost was also noted by Singh (1982).

Wheat Straw —

The influence of P levels on P content of wheat straw was found to be significant . P content due to application of phosphocompost and N, P, K was recorded as 0.052, 0.078, 0.050, 0.081, 0.054, 0.043, 0.042, 0.047,0.061, and 0.066% respectively.

Treatments having phosphocompost and N,P, K separately different doses (kg/ha^{-1}) was observed to contain. Significant increase of P in straw with the increasing order of doses.

The increase in P content (%) in grain and straw of wheat as influence by different treatments over the control plots has been worked out and presented in following table.

Table No. E

Increase in P content % in grain and straw over the control.

Sl.No.	Treatment	P - content (%)	
		grain	Straw
1	T_2	5.00	20.99
2	T_3	15.00	81.39
3	T_4	25.00	16.27
4	T_5	30.00	88.37
5	T_6	15.00	20.99
6	T_7	20.00	23.25
7	T_8	5.00	4.05
8	T_9	15.00	11.62
9	T_{10}	20.00	41.86
10	T_{11}	30.00	53.48

Uptake of P by grain and straw —

P uptake by grains was found to follow the similar trend of P content in grain and straw. P uptake was correlated significantly with the yeild of grain and straw. Maximum uptake (8.30 and 6.10 Kg ha^{-1}) was recorded in the treatment No. 5 while minimum uptake (5.11 and 2.4 kg ha^{-1}, was found in control alone (Table-23).

P uptake with the application of phosphocompost and N, P, K at different doses (kg ha^{-1}) by grain was found to be 6.20, 8.27, 7.85,

8.30, 6.47, 7.15, 6.30, 6.87, 7.43 and 8.28 kg ha^{-1} respectively and straw was found to be 3.20, 5.80, 3.00, 6.10, 3.40, 3.70, 2.70, 3.10, 4.30 and 4.45 kg ha^{-1} respectively.

N content in grain straw —

Data pertaining to nutrient concentration in wheat grain and straw after harvesting the crop was presented in table-22. It was clearly indicated that the nutrient content got increased in the similar trend as was observed with phosphocompost. Maximum nitrogen content was found with 10 tons phosphocompost and N, K (treatment No. 5). The content of nitrogen was linearly related in following increasing order over the control.

Table No. F

Nitrogen increase content (%) over the control.

Sl.No.	Treatment	(%) increase over the control	
		Grain	Straw
1	T_2	1.96	—
2	T_3	13.73	26.31
3	T_4	9.08	10.52
4	T_5	6.86	47.37
5	T_6	4.90	15.78
6	T_7	11.76	15.78
7	T_8	18.62	10.52
8	T_9	13.72	5.26
9	T_{10}	17.64	15.78
10	T_{11}	12.74	21.05

Uptake of nitrogen by grain and straw—

N uptake by grain was found of follow the similar trend to N content in grain and straw. N-uptake was correlated significantly with the yield of grain and straw. Maximum uptake (40.0 and 18.5 $Kgha^{-1}$) was recorded in the treatment No.5 while minimum uptake (30.0 and 11.2 $kgha^{-1}$) was found in control alone (Table-24).

N uptake with the application of phosphocompost and N P K at different doses ($kgha^{-1}$) by grain was found to be 30.0, 39.5, 37.0, 40.0, 33.8, 35.6, 32.8, 33.6, 36.5 and 38.7 $kgha^{-1}$ respectively and straw was found to be 11.2, 17.7, 15.1, 18.5, 14.3, 15.1, 12.9, 13.5, 16.7 and 16.9 $kgha^{-1}$ respectively.

Soil analysis after harvesting —

Analysis of soil after harvesting the wheat crop has been recorded in the table -25. The pH of soil was reduced slightly when it was treated with phosphocompost and N P K application as compared to the control. Treatments where fertilizer were applied, soils could not show any change in the pH value. The reason may be due to production of certain organic acids when organic matter decomposition takes place.

Nitrogen , Phosphorus and Potash also were determined and recorded in table-25. The total and available nutrients got increased in phosphocompost treated soils as compared to fertilizer treated soils. Organic matter (Phosphocompost) is the primary source of humus or humus like substance. It improves the structure of soil, its

drainage and aeration also increases, its water holding capacity, buffer and exchange capacities influences, the solubility of soil minerals, and serves as a source of energy for the development of micro organism (Bremner, 1956).

EXPERIMENT NO. 3

The efficiency of phosphocompost and N P K in different combinations have been evaluated on the basis of crop growth, yield and yield attributes. The results of this experiment have been properly recorded in table -26–29. and discussed here.

The height of red gram (Arhar) as affected by different doses of phosphocompost and NPK at various intervals have been presented in table-26. It clearly indicates that the plants at 30, 60 and 90 DAS increased significantly over the control. No particular trend amongst all the treatments could be observed in respect of height of plants at various intervals.

The increasing crop height at different stages of growth viz. 30, 60 and 90 DAS of red gram as influenced by different treatments over the control plots has been worked out and presented in following table–

Table -A

Increase in Crop height (cms) over the control

S.No.	Treatment	(%) increase over control		
		30 DAS	60 DAS	90 DAS
1	T_2	13.33	5.55	7.88
2	T_3	33.33	16.66	36.36
3	T_4	33.33	15.55	34.54
4	T_5	50.00	27.77	44.24
5	T_6	13.33	11.11	29.69
6	T_7	20.00	14.44	32.72
7	T_8	6.66	6.66	20.00
8	T_9	13.33	10.00	26.06
9	T_{10}	23.33	16.66	36.36
10	T_{11}	30.00	20.00	38.78

A graphic presentation regarding the increase of heights by various treatments has been illustrated in fig. . The similar findings also were observed at 60 and 90 days of sowing. The response of the added material was significant at 5% level in each case.

The persual of the data in table-27, it was noticed that the applicaton of phosphocompost and NPK increased the plant branching and it was maximum with treatment containing phosphocompost, nitrogen and potash. Mishra et al. (1982) and Abbas (1980) also recorded an increase in branching with application of phospohocompost. It was noticed that treatment - 5 had maximum increase in number of branches over the control.

Table -B

Increase in number of branches over the control.

S.No.	Treatment	(%) increase over control	
		Primary branching	Secondary branching
1	T_2	25.00	50.00
2	T_3	125.00	200.00
3	T_4	125.00	150.00
4	T_5	150.00	200.00
5	T_6	50.00	100.00
6	T_7	75.00	150.00
7	T_8	25.00	50.00
8	T_9	50.00	100.00
9	T_{10}	75.00	150.00
10	T_{11}	100.00	200.00

Phosphocompost application with N & K in this experiment has higher response over NPK and other treatments.

The effect of different P doses on nodulation and nitrogenous activity in red gram indicates that, the dose of P did not affect nodulation significantly, although the average number of nodules and their dry weights gave higher response in treatment containing phosphocompost. This may be due nitrogenase activity which was significantly more in plants treated with the phosphocompost. Phosphorus is essential for nitrogen fixation and proper growth of legumes. Single superphosphate and phosphocompost enhanced nitrogenase activity and plant growth due to better P availability to the plants.

The grain and straw yields increased significantly (table-28) on addition of phosphocompost; the increase over the control which was more than that was observed with single superphosphate. The crop yield increased significantly with the addition of compost and it also increased further with applition of phosphocompost. The effect of phosphocomost was undoubtedly found to be better which may be due to increased availability of P and other nutrients. The total P was found to be maximum in treatment (T_5) containing phosphocompost. The soil analysis of total P and available P clearly revealed that utilization of P from phosphocomost was better than other P sources.

The transformation of insoluble P takes place during composting and a part of insoluble P gets converted into water

soluble and subsequently citrate soluble. Fungi were found to transform rock phosphate P from insoluble to soluble form (Mishra et al. 1982). Chien (1979) observed that organic substances from soil release phosphate from rock phosphate by chelating Ca compounds. Since humic acid possesses chelation property, the effect of humic acid on P release from rock phosphate was investigated.

The effect of different fractions of organic matter on P release needs to be further investigated. The present studies have revealed that microorganisms and organic matter both help in the release of P from Mussoorie rock phosphate. The latter becomes a better source of P after composting with organic waste, because during composting microbial activity is high and various types of organic sustances are produced during degradation.

Analysis of soil after harvesting :

Analysis of soil after harvesting the red gram crop has been recorded in the table-29. The pH of soil treated with phosphocompost decreased as compared to the control soil. The reason may be due to the the production of organic acids during process of decomposition.

The maximum nitrogen (0.165% total and 0.0128% available); phosphorus (800 ppm total and 10.64 ppm available) and potash (1.76% total and 175 ppm available) was found when phosphocompost was added. The increase in total and available NPK may be due to the application of phosphocompost as compared to the control.

The amount of nutrients in soil, which was treated with the phosphocompost was found comparably higher than fertilizer treated soils. The cause of this increase in organic carbon was due to slow release of content by microbial disintigration (mineralization) of organic matter. Plants absorb most of the available nutrients for their growth and development. The organic matter also help to increase the water holding capacity, colour , aeration, microbial growth, organic carbon percentage and texture of the soil (Daji 1985).

The increase of available nutrients in soil after harvesting of red gram as influenced by different treatments over the control plots has been worked out and presented in following table .

Table No. C

S.No.	Treatment	(%) increase over control		
		Available N (%)	Available P (ppm)	Available K (ppm)
1	T_2	60.00	110.71	23.27
2	T_3	69.23	79.28	30.17
3	T_4	78.46	153.57	45.68
4	T_5	96.92	166.90	50.86
5	T_6	75.38	140.95	37.93
6	T_7	78.46	149.04	43.96
7	T_8	63.07	121.90	22.41
8	T_9	67.69	129.04	31.89
9	T_{10}	78.46	137.61	39.65
10	T_{11}	89.23	144.76	44.82

CHAPTER - V

SUMMARY AND CONCLUSION

SUMMARY AND CONCLUSION

The present investigation entitled "Phosphated composting on soil-plant relationship" was carried out at the Sheila Dhar Institute of Soil Science, University of Allahabad having four main objectives:—

1. Distribution of forms of inorganic phosphate in some alluvial soil profiles of U.P.
2. Phosphate potential and lime potential of some alluvial soils of U.P.
3. Preparation and study of phosphated compost and its composition.
4. Application of Phosphocompost on Paddy Wheat and Red gram crops for studying plant growth, yield and uptake of NPK nutrients.

Physico-chemical characteristics of soil are given in experiment No. 1 table (I,II,III) which are classified according to region or tract. Different fractions of inorganic phosphate in profiles of U.P. alluvial soils are mentioned in table 2 (I, II,III). Correlation coefficient (r) among various attributes are presented in table 3.

It is revealed from table 4 that soils ranged from pH 7.1-9.2 . Organic carbon has been found sufficient in quantity in most of the soils and medium in cation exchange capacity.

The phosphate potential and lime potential was calculated as suggested by Schofield and Taylor (1955) which is given in table -5. Mean values of the lime potential and phosphate potential were found to be 6.81 and 6.18 respectively. On perusal of data (Table 5) it was found that out of the 9 soils, 3 are above the mean value of lime potential and 4 are above the phosphate potential and remaining are below the mean values.

The phosphate potential, lime potential and other characteristics of 9 soils were studied which show the status of phosphate and calcium present in those soil to explore the possibility of increasing their supplying power of inorganic phosphate.

Total P content in the composts vary with differnt dose of rock phosphate which was added at the time of composting. The total P, water soluble-P, citrate soluble-P, and organic P content of phospho-compost got increased.

Fraction of inorganic P in compost showed that a major portion of rock phosphate. Phosphorus was changed in to Ca-P, and Fe-P apparently due to the presence of Ca, Fe and Mussoorie rock phosphate. The inorganic P in the compost was found in the decreasing order of abundance as Ca-P occluded Fe-P , Fe-P, Al-P and occluded Al-P.

From the chemical composition of the four phosphocomposts given in table -A, it is noted that additon of low dose of P (1% P_2O_5) as

rock phosphate in the composting material improved the total nitrogen content by about 32% . The pH value of rock Phsphate charged compost increased from 4.8 (T_1) , 5.8 (T_2) and 7.0 (T_3) and 7.2 (T_4) because of the presence of the calcium carbonate in rock phopshate. Rock phosphate also increased the calcium and magnesium content of compost.

Table - 1

Chemical characteristics of prepared Phsphocompost

Component	T_1	T_2	T_3	T_4
Total Ca (%)	1.78	2.24	4.29	5.21
Total Mg (%)	0.32	0.48	0.54	0.60
Total K (%)	0.89	0.76	0.86	0.92
Fe (ppm)	5072	12700	2864	3827
Mn (ppm)	178	498	693	829
Cu (ppm)	9	22	28	38
Zn (ppm)	56	86	132	38
Organic Carbon (%)	13.76	16.09	10.75	8.65
Total Nitrogen (%)	0.58	0.76	0.72	0.64
Total Phosphorus (%)	0.52	0.96	3.34	4.20
pH	4.8	5.8	7.0	7.2

The effect of phosphocompost and NPK in experiment no. 1 revealed that the height of the paddy crop at 30, 60, and 90 DAS increased significantly over the control. The maximum height was found with the application of N (100 kg) K (60 kg) and 10 tons phosphocompost (ha^{-1}). No particular trend among all the treatments could be observed in respect of height of the plants at various intervals.

The grain yield and straw yield of rice are presented in table - It reveals that the application of phosphate maintained the higher crop yield. The highest yield of paddy (34.8 q ha^{-1}) was recorded when N (100 kg), K (60 kg) and phosphocompost (10 tons) to the soil was applied. All the treatments were significant at 5% level over the control.

The labile P (Bray -1) status of the soil decreased as the crop growth advanced from the maximum tillering stage upto the harvest (Table - 13). At the maximum tillering stage significant variation in labile - P was noticed due to P doses. When P was given in the form of phosphocompost (10 tons), the labile P was considerable high as compared with single superphosphate. The high amount of Bray extractable -P in soil which received P as phosphocompost, nitrogen and potash indicates the beneficial effect of using phosphocompost on the paddy crop response.

P-uptake at different paddy crop growth stages viz. tillering panicle formation and harveting was found to follow the similar

trend of Bray -P at different stages. P-uptake in mg/plant was correlated significantly with the crop yield. Maximum uptake (11.7, 31.5, and 47.3 mg/plant) was recorded in the treatment No. 5 containing 10 tons phosphocompost, N and K while minimum uptake (6.5, 19.0 and 29.3 mg/plant) was found in control soil (table -14)

The perusal of the data in table -15, P-content of rice grain was markedly influenced by the application of phsphocompost at different doses. P-content in grain was found in the order of 0.256, 0.277, 0.298, 0.310, 0.350, 0.285, 0.315, 0.275, 0.300, 0.320, and 0.338 per cent due to application of phosphocompost and NPK at different doses respectively.

Analysis of soil after harvesting the paddy crop has been recorded in the table - 16. The pH of soil was reduced slightly when it was treated with phosphocompost and NPK application as compared to the control . Treatments where fertilizer was applied, soil could not show any change in the pH value. The reason may be due to the production of certain organic acids when organic matter decompositon takes place.

The application of organic matter (Phosphocompost), was found to increase the phosphorus percentage in paddy straw and grains. Maximum uptake of phosphorus was obtained with the treatment containing N K and Phosphocompost.

The effect of phosphocompost and NPK in experiment no. 2 revealed that the height of the wheat crop at 30, 60 and 90 DAS, the plant height increased significantly with application of nitrogen and

potash along with phosphocompost. The maximum height at 60 and 90 DAS stages was observed at treatment NO. 5 followed by T_4, T_3, $T_{11}$and other treatments. The minimum plant height was observed in the'control set at 60 and 90 days after sowing stages. The basal dose of nitrogen and potash alongwith phosphate supply by phosphocompost have appreciable influence on the plant height and crop growth (table-17).

Plant tillers increased significantly with application of nitrogen and potash alongwith phosphocompost (table-18). The maximum tillers at 60 and 90 DAS was observed with treatment No. 5 followed by T_{11},T_4 T_{10} and other treatments. The mnimum number of tillers was observed in the control.

The Phosphocompost and fertilizers on grain yield and straw yield were recorded in table-19. From the perusal of results from table-19 it can be concluded that the N K alongwith phosphocompost gave maximum response on crop growth. It was interesting to note that NPK and NK at different doses alongwith 5 and 10 tons phosphocompost were found to be equally effective. All the treatments were significant at 5% level over the control. Application of 5 tons and 10 tons phosphocompost significantly increased the grain yield and straw yield.

P content in wheat at different successive stages of growth as influenced by various treatments have been presented in table (21).

Data revealed that maximum amount of P was present at the tillering stage followed by jointing stage. It may be due to high requirement of nutrients by plants at primary stage and the release of phoosphate from some phosphatic source. Water soluble phosphatic fertilizers showed release of maximum phosphorus up to 30 days (Verma 1972).

In perusal of the data in table-22 P content of grain was markedly influenced by the application of phophocompost at different doses. P content in grain was found in the order of 0.21, 0.23, 0.25, 0.26, 0.20, 0.22, 0.23, 0.22, and 0.24% due to the application of phosphocompost and NPK. The influence of P levels on P content of wheat, straw was found to be significant. P content due to application of phosphocompost and NPK was recorded as 0.052, 0.078, 0.050, 0.081 , 0.054, 0.043, 0.042, and 0.047 , 0.061 and 0.066% respectively.

P uptake by grains was found to follow the similar trend of P content in grain and straw. P uptake was correlated significantly with the yield of grain and straw. Maximum uptake (8.30 and 6.10 kg ha^{-1}) was recorded in the treatments No. 5 while minimum uptake (5.11 and 2.4 kg ha^{-1}) was found in control alone (table-24).

· Analysis of soil after harvesting the wheat crop has been recorded in table-25. The pH of soil was reduced slightly when it was treated with phosphocompost and NPK application as compared to the control. Treatments where fertilizers were applied, soils could not

show any change in the pH value. The reason may be due to production of certain organic acids when organic matter decomposition takes place.

The effect of phosphocompost and NPK in experiment no 3 revealed that the height of the red gram (Arhar) as 30, 60 and 90 DAS increased significantly over the control. The maximum height was found with the application of N (15 kg), K (40 kg) and 10 tons per hectare. No particular trend among all the treatments could be observed in respect of height of plants at various intervals.

The grain and straw yields increased significantly (table-28) on addition of phosphocompost, the increase over the control was more than that observed with single superphosphate. The crop yield increased significantly with the addition of compost and it also increased further with application of phosphocompost. The effect of phosphocompost was undoubtedly found to be better which may be due to increased avaialbility of P and other nutrients. The total P was found to be maximum in treatment (T_5) containing phosphocompost. The soil analysis of total P and available P clearly revealed that utilization of P from phosphocompost was better than other p sources.

Analysis of soil after harvesting the red gram crop has been recorded in the table-29. The pH of soil treated with phosphocompost decreased as compared to the control soil. The reason may be due to the production of organic acids during process of decomposition.

The maximum nitrogen (0.165% total and 0.0128% available), phosphorus (800 ppm total and 10.64 ppm available) and potash (1.76% total and 175 ppm available) was found when phosphocompost was added. The increase in total and available NPK may be due to application of phosphocompost as compared to the control.

On the basis of the field trial and laboratory experiments it can be concluded that —

1. Rock Phosphate an indigenous P source can be profitably used as phosphocompost by applying it during compost preparation.

2. The nutritional enrichment of the phosphocompost improved the crop growth, yield and quality through increased nutrient uptake.

3. The soil fertility aspectes after the crops harvest also was favourably influenced by use of phosphocompost .

4. Application of 10 tons ha^{-1} phosphocompost was found to be most appropriate dose alongwith basal full dose of N and K for the growth, yield and quality of the crop. It can safely be recommended to the farmers on sustainable basis.

CHAPTER - VI

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